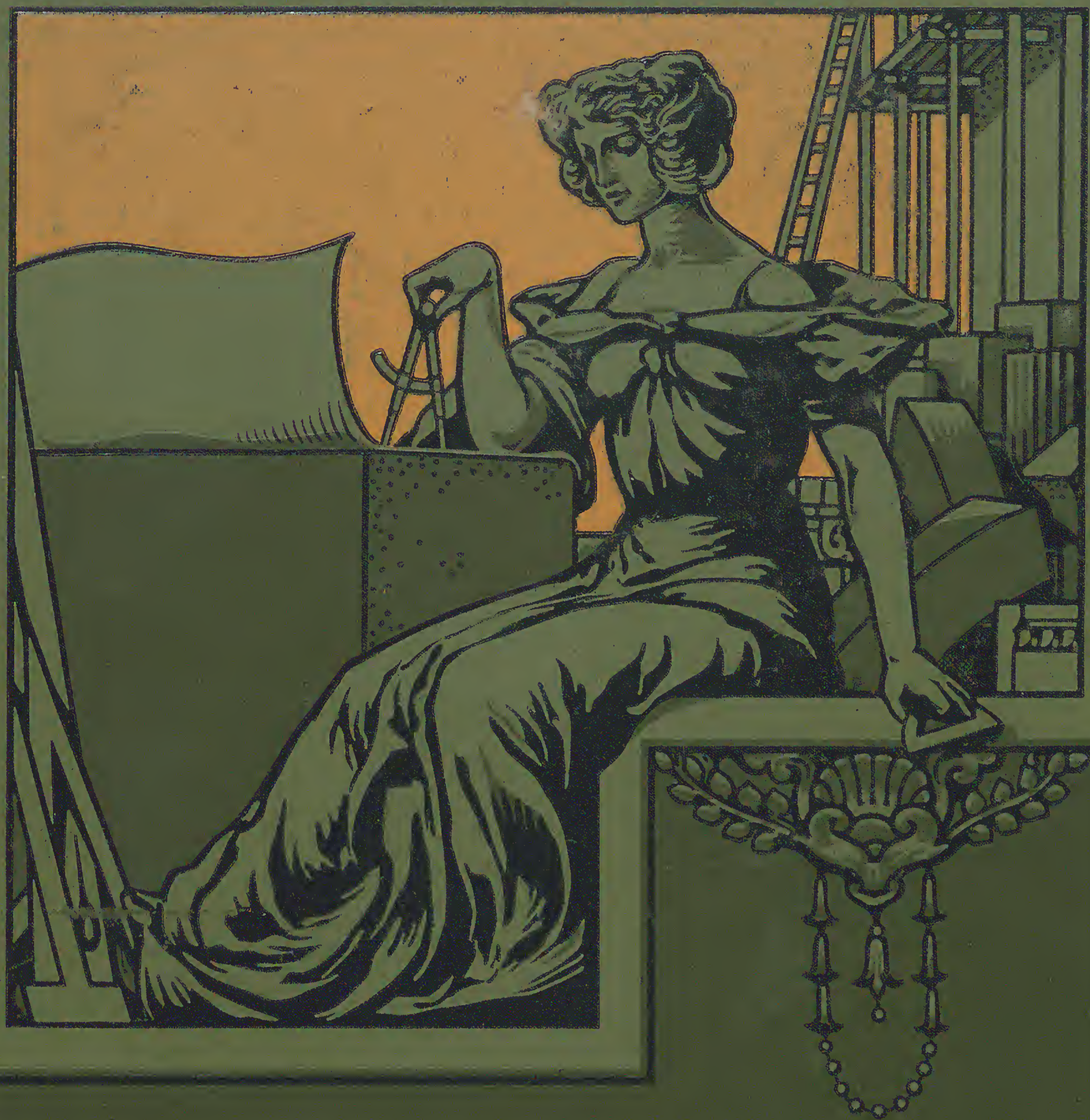

MODERN HOUSE CONSTRUCTION

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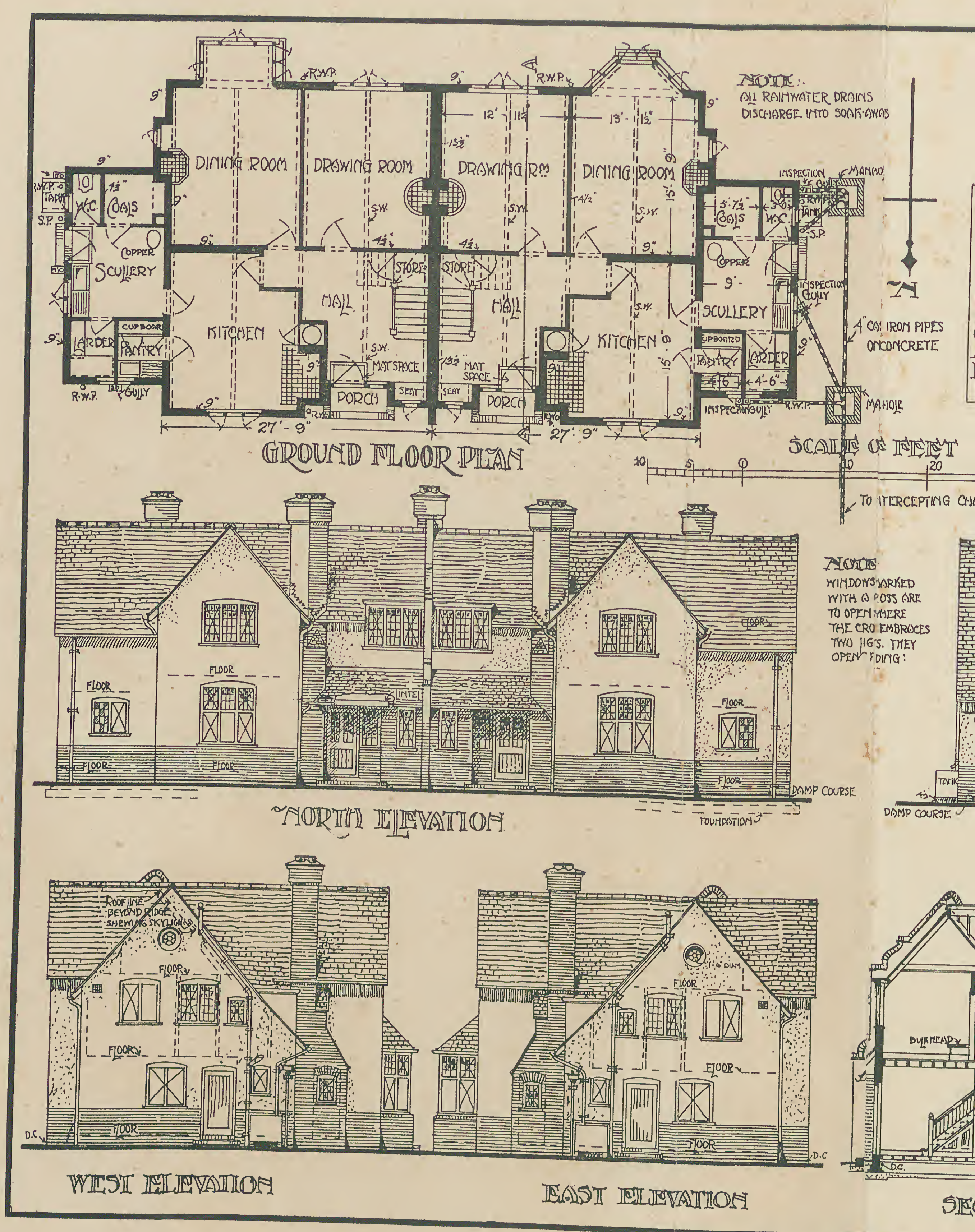
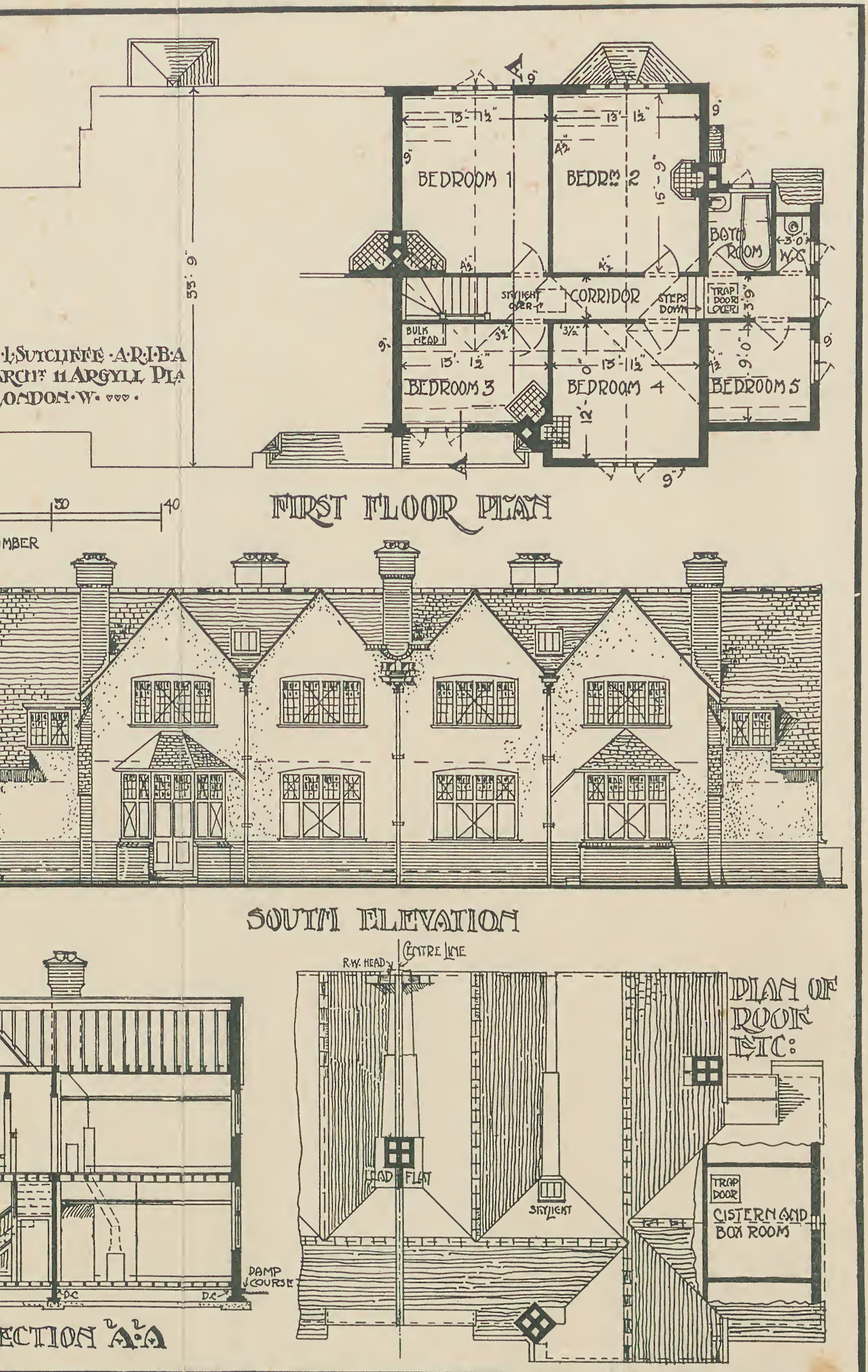


A PAIR OF SMALL SUBURBA



FIRST FLOOR PLAN
BEDROOM 1
BEDRM 2
BEDROOM 3
BEDROOM 4
BEDROOM 5
BATH ROOM
W.C.
CORRIDOR
SKYLIGHT OVER
STEPS DOWN
TRAP DOOR OVER
BULK HEAD
SOUTH ELEVATION
PLAN OF ROOF ETC:
LEAD FLAT
SKYLIGHT
TRAP DOOR
CISTERN AND BOX ROOM
R.W. HEAD
CENTRE LINE
DAMP COURSE
ECTION A-A

AN HOUSES.

The Principles & Practice of
MODERN HOUSE CONSTRUCTION

INCLUDING PLAN AND DESIGN : CONSTRUCTION : WATER-SUPPLY AND FITTINGS : SANITARY FITTINGS & PLUMBING : DRAINAGE & SEWAGE-DISPOSAL : WARMING : VENTILATION : LIGHTING : STABLES & COW-HOUSES : SANITARY LAW : &c.

BY MANY LEADING SPECIALISTS
UNDER THE EDITORSHIP OF

G. Lister Sutcliffe

ASSOCIATE OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS
MEMBER OF THE ROYAL SANITARY INSTITUTE

NEW EDITION

Thoroughly revised and considerably extended

DIVISIONAL-VOLUME I

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1909

PREFATORY NOTE

The sections into which this work is divided have been specially written by different authors, and each contributor is responsible for the section in which his name appears, and for that alone. All the sections have been carefully revised for this edition, and considerable additions have been made to the text and illustrations.

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DIVISIONAL-VOL. I

Section I.—PLAN AND DESIGN

BY

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SECTION I.—PLAN AND DESIGN.

PART I.

CHAPTER I.

GENERAL CONSIDERATIONS.

Comfort.—In no other country have the amenities of home-life been so well developed in respect of the plan of the dwelling as in the British Islands. This is partly due to the climate, and partly to the domestic habits of the prosperous classes. In other words, people are obliged to live indoors, and many can afford to make themselves very comfortable there. It is of course in the country, and in the residences of the more wealthy, that the organization of the interior of the house becomes thoroughly elaborated; but none the less in our middle-class dwellings innumerable examples may be found in which domestic convenience is almost unconsciously perfected, and the conditions of family enjoyment exquisitely fulfilled.

To make a thoroughly comfortable house, every apartment must be planned by itself, and for its own uses; and the designer will do well in all cases to take into account—in fact, to plot upon his paper plan—the disposition of the furniture. There are too many dining-rooms, for example, in which the place for the sideboard is by no means easily determined, and too many bedrooms in which there is no proper place for the bedstead; which is surely inexcusable.

Health.—That a family dwelling should be healthy, or primarily devoid of all elements of insalubrity, may go without saying; but, even in a matter apparently so simple, it does not follow that careful design can be dispensed with; indeed, the scientific question is not generally recognized as it ought to be. We are apt altogether to overlook the fact that we live in an ocean—that of the air,—the purity of whose chemical composition is life and joy to us, and its impurity disease and misery. Upon the bed of this ocean, also, we form patches of incrustation, large or small, which we call our towns, composed of multitudinous individual nests called our houses—elsewhere also scattered about singly,—in which we take up our abode and follow many of our occupations,

confining the air by unnatural restraints, compromising its purity in a hundred ways of negative neglect and positive disorganization and defilement, and, indeed, too frequently so doing with a thoughtlessness almost childish in its innocent complacency. What with our own breathing or blood-cleansing, our skin-waste, our fires and smoke, the dust from our upholstery and clothing, our drainage, sometimes our actual manufacture of pestilential vapours, all coupled with an exclusion of that supply of restless fresh air which is beneficently seeking entrance at every point, these dwellings of ours, even of the best class, only too readily become unwholesome; while in those of an inferior order, actual atmospheric poisoning is often the rule rather than the exception. The architect takes upon himself the responsibility of dealing scientifically, in the details of his plan, not only with "smells" and flagrant want of ventilation, but with a demand for brightness, airiness, proper aspect for sunshine, even prospect for cheerfulness—in short, all the environment, within and without, upon whose wholesomeness in one way or another healthy occupancy depends. Salubrity thus becomes a question of plan; and if close and stuffy rooms are generally avoidable by ordinary ventilation from the open air, and by cleanliness within (especially as regards upholstery), stuffy passages and staircases may no less be avoided by a careful consideration on paper of the facilities for producing air-currents (not necessarily draughts) by means of windows, or, where necessary, ventilated sky-lights. Damp, again, must be provided against, and the ascent of ground-air. In the case of sunk basements, nature's advice to us manifestly is to avoid altogether having habitable rooms underground; but where this cannot be done let particular care be taken to provide for atmospheric circulation under wood floors and through closed places; for the unwholesome air confined in the ground will force its way up into the warm house if it can—even through stone paving or a concrete covering. It is a good thing, also, to form emergency flues in the walls, to be turned to account if necessary.

Site.—It is no less injudicious to build our dwellings anywhere than to design them anyhow. In the open country, whether it be a stately mansion or a humble cottage, or, more usually, a comfortable family home, the situation of the house is most important. Where freedom of choice is unrestricted, let first the front containing the entrance, secondly that containing the garden windows, and thirdly the offices, be so planned separately as leading features, that never on any account can they be confused together. On the contrary, so dispose them that each façade of the house shall serve effectually by itself its own proper purpose—the entrance-front that of convenient ingress and egress, the garden-front that of bright and cheerful family privacy, and the

offices-front that of the special operative department to which it pertains. For instance, it is quite inadmissible for the carriage-drive to pass through or along the lawn; or for the tradesmen's carts to use the principal approach; or for the kitchen-entrance to be in sight of the family rooms; or for the lawn or garden to be overlooked by the servants. Even in very modest dwellings something like a recognition of these elementary rules may be observed. To a considerable extent also in towns the same principles may be applied. Fig. 1 shows an example of typical treatment for a suburban house of good size.

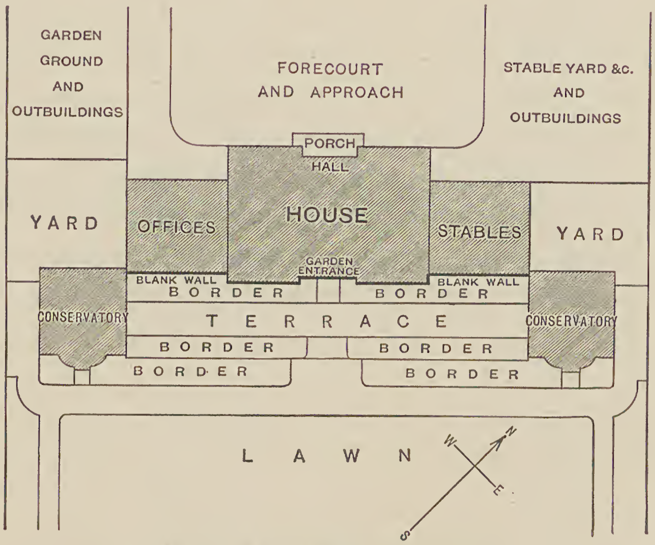


Fig. 1.—Site Arrangement: Suburban Type.

Aspect and Prospect.—It is astonishing that so few people consider the question of aspect. That of prospect or agreeable outlook is not generally neglected; but the elementary fact that aspect, or the influence of the weather and sunshine upon the house within, is of paramount importance, seems to be almost unknown. The aspect-compass here introduced (fig. 2) may be usefully studied. All the year round and everywhere in our hemisphere the sun is south at noon, and sunrise and sunset always at about equal distances therefrom eastward and westward; the sunshine lasting from about 6 A.M. till 6 P.M. (12 hours) at the March

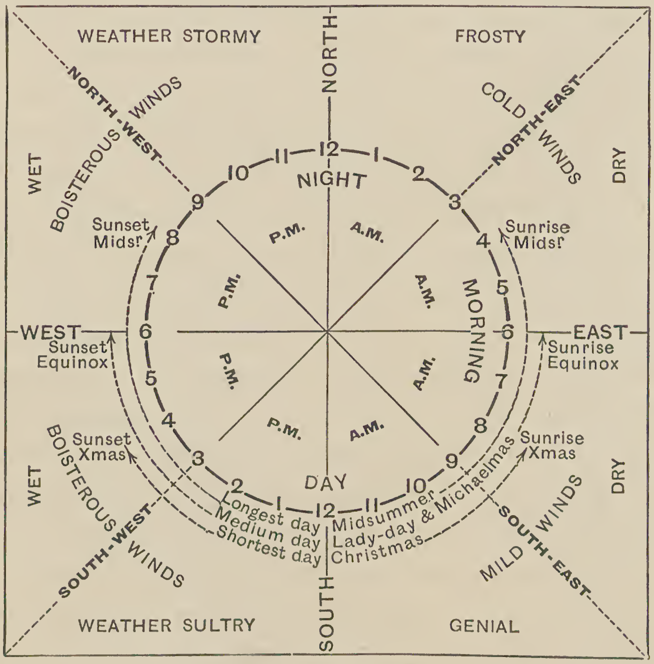


Fig. 2.—Aspect Compass.

and September quarter-days or equinoxes. In the south of England the sunshine lasts from about 8 A.M. till 4 P.M. (8 hours) at Midwinter or Christmas, and from about 4 A.M. till 8 P.M. (16 hours) at Midsummer. In our country, northward aspects are cold, and southward warm; the north-eastward catches cold winds, and the north-westward and south-westward boisterous winds; the south-westward is wet, and the south-eastward dry and mild. Sultry weather tells most oppressively upon a room which catches the afternoon sunshine by facing south-westward or westward, and the westward sunshine coming into a room is also at a disagreeably low level; the position of the sun being of course in all cases north-east at 3 A.M., east at 6, south-east at 9, south at 12 noon, south-west at 3 P.M., west at 6, north-west at 9, and north at 12 midnight. It follows, therefore, that for coolness and shade generally, windows should look more or less northward; for the morning sunshine, eastward; for mid-day sunshine, southward; for evening sunshine (or the sunset-prospect), westward; for morning coolness, westward; and for evening coolness, eastward; and the best compromise to suit most purposes is the south-eastward. We must remember, too, that sunshine in itself is an important health-agent, and the house may be so arranged that the principal rooms shall be well "sunned" in the early part of the day, and left to cool afterwards in such a way as shall be convenient and comfortable to the inmates. For instance, to be obliged to keep the window-blinds of certain rooms drawn down almost all day long, or to have other rooms insufferably stuffy in the afternoon although the sunshine is off the windows, is obviously an unfortunate state of things.

Light and Air.—This phrase is in very common use in England with a somewhat special meaning, owing to the law of "ancient lights", under which a building owner A is obliged to avoid interfering with the windows of his neighbour B as regards the access of light over A's property when this has been enjoyed for twenty years; the access of air also being held to go with the access of light. But, apart from this, it is obviously essential to the comfort, convenience, and salubrity of any dwelling, that the designer should particularly keep in view two elementary and self-evident maxims, namely, that every room, passage, and stair, and every corner in the house, should be not only lighted, but as far as possible abundantly lighted, and that any unavoidable compromises should be carefully and even anxiously adjusted; and further, that the inlet of fresh air from without, and the outlet of vitiated air from within, should be left as free as possible for the operation of kind Nature's fundamental desire to bring down the one by gentle force to every spot where it is wanted, and to bear the other upward and away. It is true that the human struc-

ture is endowed with a wonderful measure of endurance against darkness and suffocation, but it is the architect's duty that the presence of these baleful influences shall not be due to him. He must therefore take every care that his windows shall be, both in position and size, quite adequate to the work they have to do; not extravagantly large (because of the consequent heat and cold), but sufficiently large, and also judiciously placed; in fact, the window design of a dwelling is so far the light and air of the dwelling, and greatly affects its salubrity.

Spaciousness and Compactness.—To accomplish economy of space, and yet avoid cramping the plan, is of course a work of skill, and a result to be greatly commended. For compactness in most cases means both convenience and comfort, and a rambling arrangement inconvenience and discomfort. At the same time, the element of spaciousness or general roominess may certainly be coupled with that of compactness without any real sacrifice; while, on the other hand, confined and narrowed arrangements in detail may often be found associated with a disjointed and wasteful general plan.

Elegance.—Nothing has to be said here in the way of advocating mere elegance of proportions or artistic style as a consideration in the design of the plan of a dwelling; but what is worthy of remark is that the enthusiasm for fine-art has been somewhat too apt at times to compromise the utilities of house-building. Surface-embellishments may be lavishly employed in the interior without being complained of, but when the elementary conveniences of home-life are sacrificed to the fanciful demands of a fashionable archæological mode, objection surely may be raised. Fashionable Greek and fashionable Gothic having now both had their day, we may safely allude to the fact that they were both uncomfortable; and we may add that when an architect, who wishes to be in the fashion now, feels bound to insist upon having small windows purposely obscured, or upon introducing picturesque little flights of steps where no steps should be, his client need not hesitate to request, with all respect for genius, that he would be so obliging as to reserve such amenities for some more appreciative client.

Style of Plan.—There is a perfectly legitimate offer of choice in respect of the general plan of a house. That is to say, it may be laid out on principles of picturesqueness, quaintness, irregularity, and surprise; or on principles of regularity, symmetry, and repose. It is enough to add that some people prefer the one style, and some the other, as matter of sentiment; and that comfort, convenience, and salubrity may be fully achieved in either; subject only to this consideration, that even stateliness may have its drawbacks, as eccentricity

unquestionably has. For good ordinary middle-class residences, the simple "square house" plan, so generally adopted by the last generation, is abundantly exemplified in suburban localities all over the country, with its central entrance-porch, hall, and staircase, dining-room and offices on one side, and drawing-room, &c., on the other. The manifest advantages here are symmetry, simplicity, and compactness. But the present generation prefers greater freedom of arrangement, the rooms must be disposed more independently, declining the restraints of symmetry, and the grouping may go as it pleases. The benefits of liberty are still evident, but we have to guard against equally obvious temptations.

CHAPTER II.

LIVING-ROOMS, BEDROOMS, AND THOROUGHFARES.

Thoroughfares.—The work of planning a house as a whole may almost be said to begin with laying out such a framework of thoroughfares—that is to say, entrances, passages, and staircases—as shall conveniently and appropriately accommodate the internal traffic, and place every apartment in its proper relation to all the rest. Although every room taken alone may be perfectly planned and perfectly furnishable on the proper principles, yet if this grouping of them all has not been satisfactorily accomplished, the house must be pronounced radically imperfect. Compromise may enter, and always does enter, into the adjustment of conflicting arrangements in detail, but it ought to be confined to a minimum, and a perfectly convenient and comfortable house possesses, as a first principle, perfectly convenient and comfortable thoroughfares.

In every house of large or moderate size there ought to be certain arterial lines of thoroughfare clearly distinguishable. The first, on the ground-floor, leads from the front entrance through the hall, through or past the staircase, to the garden door. A secondary line branches off from this through the offices and by the back stair to the servants' entrance. The first accommodates the family traffic, the second that of the service. Upstairs the family traffic proceeds from the staircase to the bedrooms and dressing-rooms in succession, the nurseries, the bath-rooms and closets, and terminates at the back stair; and the servants' bedrooms have their own line of access commencing there.

One of the very chief considerations is the lighting; semi-dark passages and staircases are inexcusable, however common they may unfortunately be. In

the country, where the site is free and open, defective lighting ought to be impossible; but even in the town, professional skill need never be so unequal to the occasion as to be satisfied with a dark passage or a blind stair, any more than with a dismal drawing-room or a gloomy kitchen.

The **entrance-hall** is too often treated as only a vestibule, but it is properly a rendezvous, and even in street houses space is well expended in making it as commodious as possible.

A staircase is most important as a chief thoroughfare. Airiness and good lighting by wall-windows, and not by a sky-light in the roof, are indispensable if the comfort of the house is to be assured. Winders or "turnsteps" should be avoided if it be possible; and the shallower the riser the broader must be the tread, so as to keep the stride nearly equal. In small houses a staircase readily carries an odour upwards, notably the smell of cooking. Odd steps in dark corridors are a blemish in any plan. Again, a single step at the door of a room is, as a rule, objectionable. Of course, a step is required at an external door to keep out the rain and dirt and to raise the floor above the ground outside, and one or two steps down from the main floor into a coal-place, wash-kitchen, or other room where there is much dust or water, are also useful.

Living-rooms.—In a house suitable for an unpretentious family of the middle class, the primary living-rooms are a dining-room for meals, a drawing-room for the ladies, and a supplementary apartment for the master of the house, usually taking the name of "library" or "study". As the establishment advances in rank, a more proper library is substituted for the last, to accommodate gentlemen-guests and visitors; after which a billiard-room, a gentleman's room or "business-room" for the master's privacy, a subsidiary drawing-room called the "morning-room" for the ladies, and a boudoir or private room for the mistress, are successively provided, and sometimes a subsidiary dining-room called the "breakfast-room". On the other hand, in dwellings of less degree the dining-room is used as the general sitting-room, and the drawing-room chiefly for the reception of visitors, while the supplementary room, if any, is occupied according to circumstances—sometimes as a children's room. In still simpler households the dining-room becomes the family parlour, and the drawing-room, if retained, is only the best parlour for occasions of ceremony.

In all these rooms alike, there are three leading features in the plan, namely, the fireplace, the one or more windows, and the door; and, speaking generally, the fireplace is best placed in the middle of one of the sides of the room, the window or windows in the middle of either of the two sides at right angles to this, and the door in either of the two remaining walls close to that corner which

is most removed from both fireplace and window (see fig. 3). Whenever possible, the fireplace should be against an internal wall, as smoky chimneys are particularly to be feared in external walls, because of the effect of atmospheric cold on the flue; indeed even tall chimney-stacks are liable to produce the same result. Keeping in mind this general type for simple plans, there need be no difficulty in dealing with more complex cases.

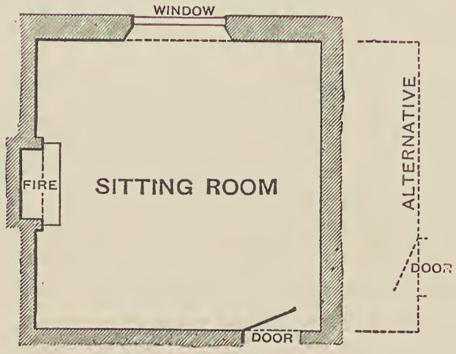


Fig. 3.—Sitting-room: Primary Type.

Nos. 1 and 2, fig. 4, show two very objectionable plans, one of a sitting-room and one of a kitchen, actually carried into execution to meet the exigencies of "style". In both cases the relation of the door to the fireplace could not be worse.

In **a dining-room** there are two other features to be considered, namely, the dining-table and the sideboard. If the sideboard is opposite the fireplace, the mistress of the house is properly seated with her back to the fireplace, at

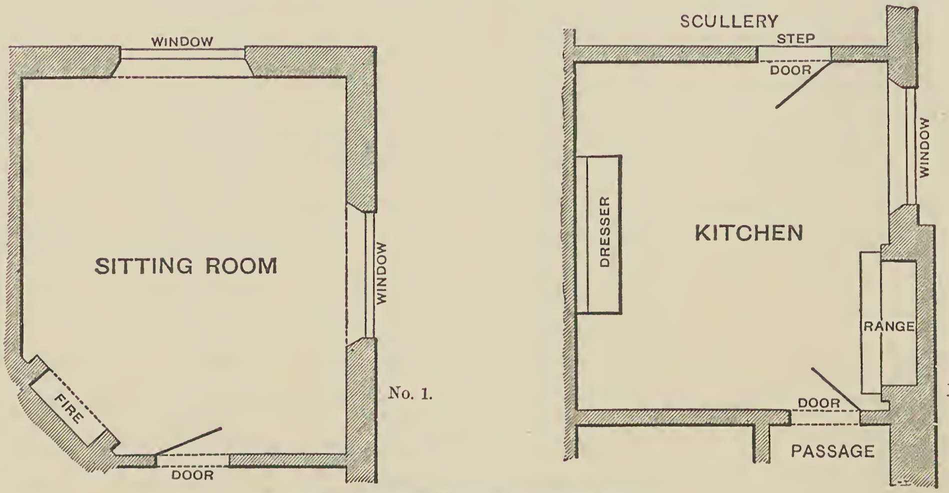


Fig. 4.—Bad Examples of Sitting-room and Kitchen.

the "head" of the table; and the master with his back to the sideboard, at the "foot" of the table; the origin of the latter arrangement being that the master is supposed to be in touch with the butler and the wine. The fireplace and the sideboard ought therefore to be placed on the end walls of the usual oblong room rather than on the longer side walls. The door is then to be placed at the sideboard corner in the wall opposite the windows, rather than in the sideboard end wall; but a second door for service may be provided at the further end of the

sideboard wall (see fig. 5). To allow for easy service around the table, the clear width of the room ought not to be less than 14 feet, but the question of cost often necessitates a narrower room.

A drawing-room may be planned according to fancy, provided that the fireside is disposed in pursuance of the rule of comfort, and the door or doors rightly placed with relation to it; in other respects even a fantastic arrangement, within rational limits, becomes permissible; the only vital objection to this license being that all eccentric things, however pleasing at first, soon pall upon the taste. The aspect of a drawing-room ought to be south-east, and the prospect pleasant.

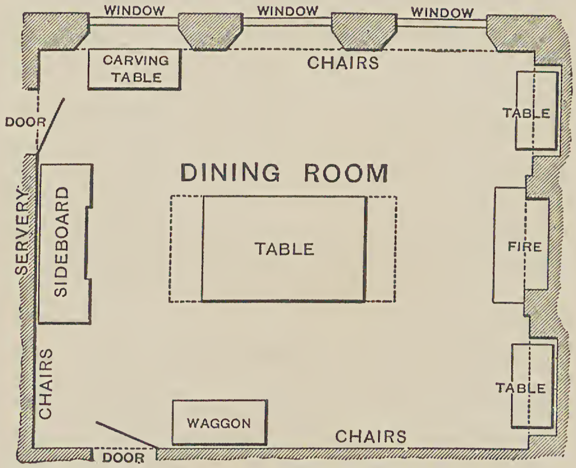


Fig. 5.—Typical Dining-room.

A morning-room ought to be a simply-designed apartment for the commonplace purposes of unceremonious feminine home-life, the license of eccentricity and the burden of restraint being alike out of place. Here again the aspect ought to be south-east or a little more eastward, and there should be a ready outlet to the lawn, perhaps by a casement-window. A comfortable fireside is essential, and suitable places should be provided for a writing-table and for work-tables; also a good position for a piano.

A boudoir is similar to the morning-room, but on the principle and scale of a strictly private instead of a more public room; it is also practically the mistress's business-room, from which the household management is directed, and a particularly methodical lady may have a sort of office-table or escritoire for a conspicuous feature. Otherwise it may be merely a very dainty retreat for refined seclusion, with a minimum of business; and sometimes it will be on the bedroom floor of the house, in which case it ought to be of very easy access from the principal staircase. The aspect and prospect ought both to be of the best.

A gentleman's room is, so far as privacy goes, like the boudoir, but of a thoroughly masculine and more business-like order. On a country estate it is, in fact, the estate-office, and may have a clerk's room attached. A professional man will perhaps make it in like manner purely a business-room. The aspect is preferably in the shade, say north-eastward. The access ought to be of twofold convenience, in the first place for visitors of importance entering

the house by the front door, and in the second place for others who come through the servants' offices.

A library, properly so called, is of course a book-room, surrounded more or less with book-cases, and furnished with reading and writing appliances and very comfortable chairs, &c. In good houses it is the gentlemen's public morning-room or lounge. An eastward aspect is desirable, and the lighting is important. A study or small library is frequently a problem of some difficulty. Fig. 6 represents a good model; the occupant sits with the fire-place at one side and the light at his left hand; his book-cases also are well lighted, the door is as it ought to be, and he has a good place for a side-table, an easy-chair for a visitor, and a pleasant fireside.

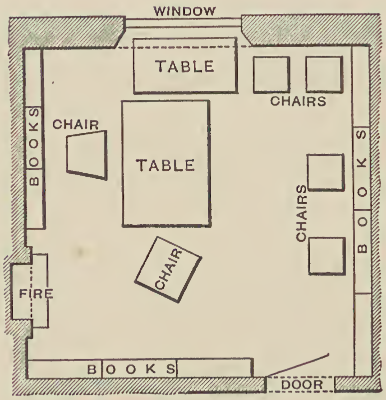


Fig. 6.—Typical Study.

A billiard-room is not a thing to be planned anyhow if it is to withstand the criticism of even the least-accomplished players. The table, twelve feet by six, ought to have a space of six feet or more all round it; and the lighting ought to be by a ceiling-light immediately over the table and of the same dimensions; wall-windows may be used when better cannot be had, but at best they are only a make-shift. When, as is perhaps most frequently the case, the billiard-room is used as a lounge for gentlemen, there ought to be a comfortable fireside at one end, with sufficient extra floor-space. It is important that a billiard-room should be well ventilated artificially. The well-known three pairs of strong hot lights for evening use render this especially necessary; more particularly if the room is to be used as a lounge during the day, and perhaps as a smoking-room, and still more if ladies are to play after dinner or to look on with comfort.

A smoking-room, if so called, is, more properly speaking, a free-and-easy lounge where smoking may be carried to excess without the risk of offence, and which may be confidently used for any casual masculine purpose.

A parlour, or unpretending family living-room taking the place of the more formal dining-room, is primarily a sitting-room, having a good fireside at one end and a sideboard at the other, a table in the centre for meals and all other purposes, a pair of easy-chairs, a couch, and the usual miscellaneous furniture. If there be a second or best parlour, so called, it will be simply a somewhat superior room of the same type, taking the place of a drawing-room.

A breakfast-room in a good house is a subsidiary dining-room, similarly

furnished, but in a more homely style, and used by the family for breakfast. It is placed somewhat eastward accordingly, and is available for children's meals, and perhaps for parlour purposes at pleasure. In London houses of modest pretensions one of the basement-rooms is often the breakfast-room, the kitchen being conveniently situated near it.

A conservatory as an adjunct to the house may be best described as a glass room attached to the ladies' quarter; preferably to the hall, staircase, or garden entrance; never too directly connected with any of the family apartments (because of the moistened air); calculated for only a moderate temperature; and, of course, sufficiently exposed to the sunshine. The less crowded it is, and the more like an elegant lounge, the better. The plants are its garniture more than its mere contents.

A verandah with a sunny aspect—preferably south-west—is a very pleasant adjunct to a country house. It ought, however, to be so placed as not to obstruct the light to any of the rooms, and ought to be of sufficient breadth to afford shelter from the sun and wind.

Bedrooms.—Every person who has experienced the satisfaction of occupying a thoroughly comfortable bedroom must have seen how much its proper arrangement, whether as regards the planning of the room itself or the disposition of the furniture, becomes identified with its comfort. It is true that the bedroom-floor of a house, as a whole, has to follow the lead of the ground-floor, and no less that the principles of plan of the two stories and their requirements may not correspond. Compromise, therefore, must of necessity enter into the solution of the secondary problem; that is to say, wherever the living-rooms below and the sleeping-rooms above are at variance, it is the sleeping-rooms that must give way. But it does not by any means follow that the bedrooms are to be negligently dealt with; on the contrary, the earnest designer must devote all the more trouble to them.

A bedroom, just as much as a living-room, ought to be planned within itself, or strictly upon internal conditions; and it is most essential that the furniture should be plotted on the drawing. The governing features are not only the one or more windows, the one or more doors, and the fireplace, but obviously the bedstead, the dressing-table, the wash-stand, and the wardrobe; and the problem of plan is to find a proper place for each in relation to all.

The standard bedroom is one for the accommodation of a married couple. It is the custom for the lady to use it also for dressing, a small adjoining dressing-room being provided for the gentleman. In planning an ordinary or typical suite of this kind in the simplest form, and taking the bedroom

first, the window may be considered as a fixed point. Whether to place the bed or beds opposite the window, or against one of the other walls, then becomes a sort of personal question; for some people when in bed object to a glare at the foot, while some have the same objection to a glare at the side. The fireplace will preferably be in the middle of one of the other walls, and the wardrobe in the middle of the remaining one. The dressing-table then is placed against the window, and the wash-stand preferably towards one corner well in the light, and there is another corner for a chest of drawers. As regards **the dressing-room**, the first thing to bear in mind is that there must be a place for an emergency bedstead, probably, if the room be small, in the corner away from the window. The fireplace, wardrobe, and wash-stand may then be accommodated according to circumstances. The door of intercommunication with the bedroom ought to be removed from the outer door, and also from the fireplace. The dressing-table goes to the window.

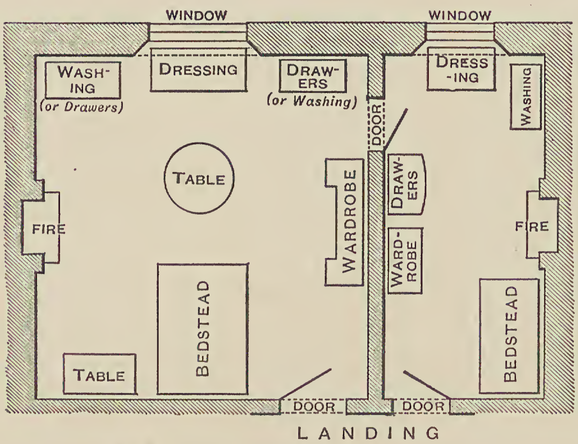
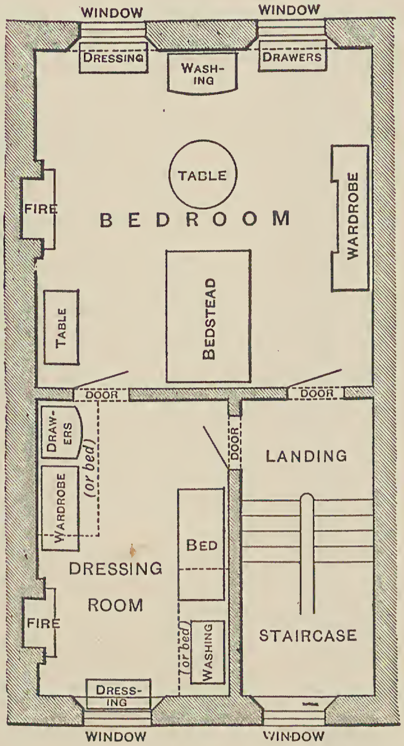


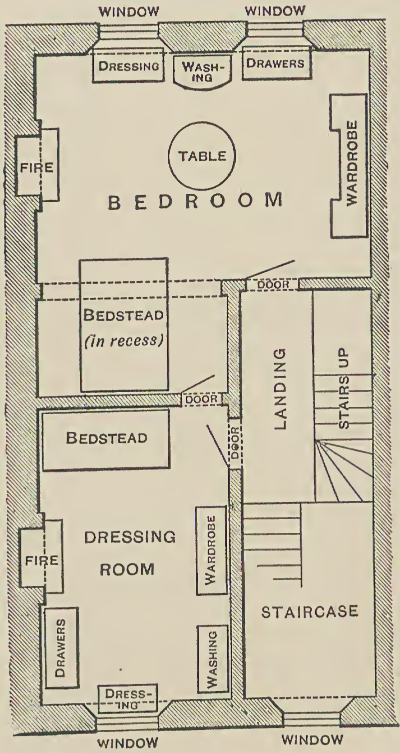
Fig. 7.—Typical Bedroom and Dressing-room.

Several illustrations must be given under this important head. Fig. 7 represents a good standard arrangement when the rooms are sufficiently large. In the bedroom the bedstead is placed with its foot to the light, standing centrally against the wall, and the wardrobe occupies a central position opposite a central fireplace. The outer door is in the position which is most usually accepted, but one which has an obvious disadvantage in relation to the bedstead, although it would undoubtedly be still more objectionably situated if in the wardrobe wall. The door to the dressing-room is conveniently situated for both sides. A centre table has frequently to be accommodated, but this involves no difficulty if the room be large enough; a bedside table is also shown. The wash-stand may be at either side of the window, and the chest of drawers at the other. Space must be left for a good fireside, which it is so often essential to maintain. Turning to the dressing-room, it will be seen how a good position for a bedstead becomes a primary consideration; the fireplace need not be central, the wardrobe and drawers are well in the light, and so is the wash-stand. Of course the arrangement as a whole admits of modification where the general plan of the house requires it.

No. 1, fig. 8, shows a similar plan for an ordinary street house on the well-known London model called "two rooms on a floor". The bedroom arrangements are the same as in the last instance, but in the smaller apartment in the rear, shown as the dressing-room, a little difficulty arises as to the place for the bedstead. There are three alternatives. Firstly, it may be put in the inner corner opposite the door of entrance (as dotted); which may require the sacri-



No. 1.



No. 2.

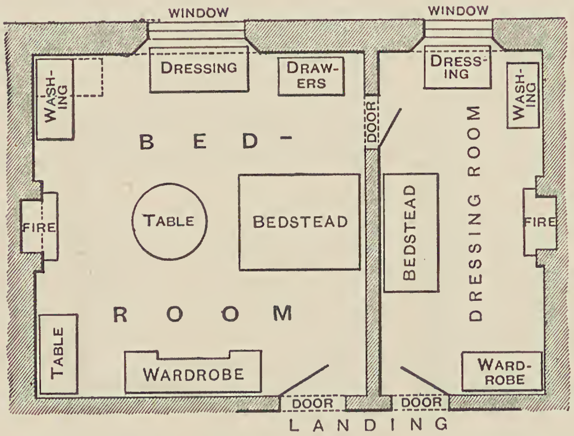
Fig. 8.—Bedrooms and Dressing-rooms in Street House.

fice of the door of intercommunication. Secondly, it may be put in the corner next the window (as also dotted); which raises the question of a draught. Thirdly, it may be placed, as here represented, against the middle of the staircase wall, and the sleeper may make either end the head as he pleases. The wardrobe gives no difficulty; and the fireplace in any case need not have a central position.

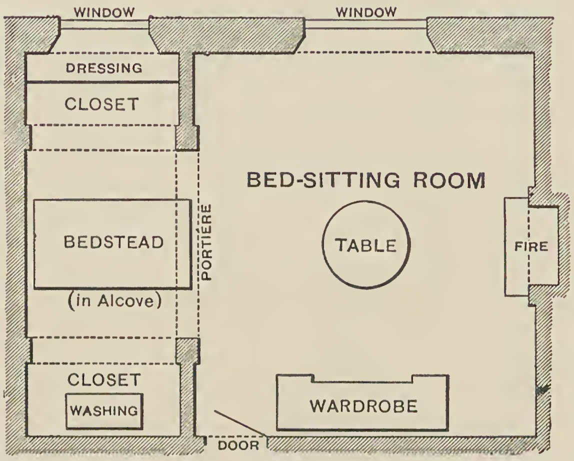
No. 2, fig. 8, shows another plan for a street house, which has certain advantages. The stair-landing being extended to accommodate a separate flight for the story above, the bedroom becomes L-shaped, so that the bedstead stands in an alcove secluded from the door. The dressing-room bedstead then occupies an inner corner sideways to the light, the door of communication

has a suitable place and allows a free circulation of air through the recess in the bedroom, and the fireplace may be central.

No. 1, fig. 9, shows the bedstead standing sideways to the light (but exposed to the door), the fireplace is central opposite, and the dressing-room has its two doors, its bedstead well placed, and its fireplace central. Otherwise this bedstead may be in the corner, and the fireplace out of the centre.



No. 1.



No. 2.

Fig. 9.—Bedroom and Dressing-room (alternative to fig. 7) and Bed Sitting-room.

A sort of French bedroom or **bed sitting-room,** especially suitable for young ladies, is shown in No. 2, fig. 9. It has a bed-alcove, which may be screened off during the day by a *portière*; the two side closets serve for washing and dressing respectively, and the main area of the room is free from all sleeping-room furniture except a wardrobe and probably a cheval glass.

In cases where dressing-rooms must be dispensed with, and the bedrooms themselves are of diminished size, the principles above indicated ought to be followed out as best may be, but in no case is it excusable to pass such a room on the paper plan until the bedstead, window, door, and fireplace have all been plotted thereon in a sufficiently satisfactory relation to each other.

On the other hand, a **bed-chamber suite** on a superior scale is perhaps all the more easily designed. It is simply a group of rooms, comprising a bedroom, two dressing-rooms, perhaps the boudoir besides, a wardrobe-room, a bath-room, a water-closet, and, for access to the whole, a lobby or corridor with its own private door. The general principles of arrangement are still the same.

Every bedroom of sufficient size ought to be designed with an eye to the

chances of occupation by an invalid; and in many cases of even the most temporary illness it may be found extremely desirable to have a second room in communication, available for the nurse's work. The ordinary dressing-room will suffice. A door towards an adjacent bedroom is objectionable.

Children's rooms ought to have a sunny aspect. In very complete form these will constitute a suite, comprising a night-nursery, a day-nursery, a nurse's private room, a private corridor with its own outer door, a bath-room, a water-closet, a wardrobe-room, and perhaps a little scullery, and a larder or milk-store. The night-nursery ought to be carefully planned so as to accommodate a sufficient number of little bedsteads kept clear of draughts, with a comfortable fireside and plenty of light and air. The day-nursery also must have a good fireside, and be well lighted and ventilated; and the furnishing will probably have for its basis a large square central table for elementary school-work, &c. In a permanent family residence the necessity for a school-room ought to be kept in view, with a governess's room close at hand; and both of these, and the nurseries as well, ought to be available as ordinary bedrooms when not specially in use. Cupboards and closets are particularly useful for children's rooms; and there must be ready access for the mother at night.

CHAPTER III.

DOMESTIC OFFICES AND SUPPLEMENTARIES.

One characteristic of a well-planned house is that the family department and the servants' department are distinctly separated. It is not, as some might suppose, that allowance has to be made for class feeling as between superiors and inferiors; it is simply that the family desire to enjoy freedom from interruption, and that the servants have the same objection to be unduly disturbed or overlooked. In other words, there are two sections of the household both equally entitled to privacy so far as their relations to each other admit; and accordingly, the offices as a whole have always to be grouped together on the same principle, whether in a small house or in a large mansion. Of course there are classes of households in which no distinctions of social status have to be observed, in which case the separation in question may not come into view; but even then the principle need not be ignored.

The first in order of the domestic offices is **the kitchen,** and the leading feature of its plan is the cooking-range. This ought to occupy preferably a

central position in one of the longer walls of the usual oblong room, and in front of it in the middle of the room there will be the large kitchen-table. The window-light ought to be on the left hand of the cook when engaged at the range, and the kitchen dresser ought to stand conveniently adjacent to the table. Miscellaneous apparatus is now manufactured in so much competing variety that it is mere matter for choice in the warehouse, and need not be described (see fig. 10). But the cook's closet must not be forgotten, in a handy position for constant access, and the door of entrance to the kitchen ought to be near one corner, and must not incommode either the fire or the traffic. **The scullery** is an apartment which ought to be directly connected with the kitchen, and the door between the two ought to be as near to the range as possible; to have to cross the kitchen to reach the scullery is very objectionable; to have to cross a passage outside is fatal. The scullery will have a fireplace containing a small supplementary range, one or two coppers or other boilers, and one or more sinks; and there must be a door of entrance besides the door of intercommunication with the kitchen. The light to both kitchen and scullery ought to be ample, with an aspect northward or eastward. Ventilation ought to be carefully provided for; if the work to be done is on a liberal scale it may be desirable to increase the height of the ceilings. An outside door in the scullery is often desirable, but not in the kitchen. In small establishments the principle of plan is the same as in large, the scale of the apparatus and accommodation being proportionately reduced. Fig. 10 shows a good arrangement of kitchen and scullery, with larder and pantry, and outside access or so-called "tradesmen's entrance". The kitchen corridor also is designed with a motive. The lobby at the out-

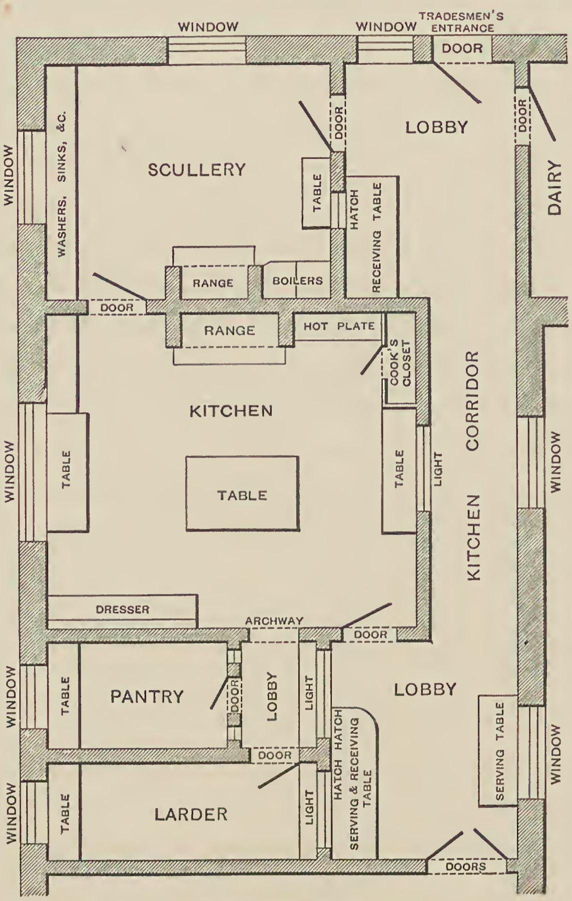


Fig. 10.—Kitchen Suite.

side door is made to accommodate a table for receiving supplies, and a similar table is provided in a special recess near the larder. The kitchen door is placed out of the line of the corridor traffic. An indication is likewise shown of the principle of inclosing when possible the corridor as a whole, and the borrowed lights throughout are chiefly for ventilation. Hatches for the scullery and the larder, as shown, are useful for taking in the supplies. The purpose of this illustration is chiefly to suggest a large number of convenient appliances, the distribution of which, and indeed their introduction, must depend upon circumstances.

It will be observed that the scullery is on one side of the kitchen, while **the larder and pantry** are on the other. The scullery is necessarily at times a somewhat uncleanly adjunct, while the larder (for uncooked meat) and the pantry (for cooked) must be carefully protected against any pollutive influence. Therefore to make these open out of the scullery is inadvisable. Bread and pastry, and perhaps milk and butter, are kept in the pantry, and vegetables and cured meat in the larder; but no special provision need be made in either case. When **a dairy** is required, it ought to be so far separated from the kitchen offices as to be kept fastidiously clean and cool; and the work of cleansing the dishes ought to be easily taken therefrom to the scullery, or to the open air. All these offices must have a cool aspect.

When the domestic offices occupy a **sunk basement,** there are special difficulties to be contended with as to lighting and ventilation. Dark passages and a dimly-lighted stair are frequently found even in good houses. Wide open areas, extending as far as possible, are the best substitute, although by no means an equivalent, for the open air; and ventilating flues in the walls may be made very useful. Sleeping-rooms in a basement are not to be sanctioned.

The butler's pantry demands a peculiar position. It must primarily be close to the dining-room; and it has no connection with the kitchen-department, except for service. It has also to be conveniently situated for attending to the entrance-hall, and likewise for commanding the back entrance, although it must not be easily accessible to the light-fingered class. There may be a plate-closet or safe attached to it, and sometimes there is also a little private scullery for the cleaning. The butler's bedroom is a necessary adjunct in large houses for the protection of the plate.

The servery is an appendage at the sideboard end of the dining-room, in fact an anteroom towards the butler's pantry. In small houses the service has to take place from the corridor, and very frequently through the only door of the dining-room; in which case it is always desirable to provide space for a

serving-table outside the room. In superior houses the servery may require a hot closet for the purpose of keeping a ceremonious dinner warm. When a kitchen of importance has to be in the basement story, there ought to be a dinner-lift, but not opening actually into the dining-room.

"**Maid's pantry**" is the name often given to a butler's pantry on a minor scale where no men-servants are kept. It is fitted with a deep sink, and with cupboards for glass, china, &c.

The housekeeper's room in large establishments is the sitting-room and business-room of the housekeeper, and the dining-room of the upper servants; the lady also is enabled to give her directions there. In smaller houses, where there is no separate housekeeper, it may still keep the name—or preferably that of housekeeping-room—and be a business-room and special store-room, and even a working-room for a thrifty mistress. In either case, the leading feature is the series of closets or cupboards which contain the groceries and dainties, china, glass, and table-linen in use. In yet smaller houses **the store-room** takes its place; while in larger houses there will be a store-room besides the housekeeper's-room, taking the supplies of chandlery and the like. Sometimes a **china-closet** may be provided for the purpose implied by the name, and occasionally a **still-room** for making the tea and coffee, &c. All these offices ought to be well lighted, if only to avoid breakages and confusion.

The servants' hall is the living-room for the lower servants,—or for all, if few in number,—used for their meals and evening accommodation, also for miscellaneous work, and for the reception of visitors' servants and other persons of the same rank; the housekeeper's room and the butler's pantry being similarly utilized in their own way. In small houses the kitchen has to serve for all such purposes, supplemented by the housekeeping-room if there be one. A typical servants' hall ought to be situated near the back entrance, also near the kitchen for service of meals, and sufficiently near the butler's pantry. It ought to have a comfortable fireside, and be cheerfully lighted.

A housemaid's closet is a small place on the bedroom floor, containing a sink, and accommodation for brushes, dusters, pails, cans, and so on, with water-supply. It ought to be placed near the back stairs, and in a sufficiently sheltered position. **A brushing-room** is a small place in a superior house for brushing garments. **A lamp-room** in a country house is a place for keeping and lighting the lamps; not a cleanly place, although not to be kept dirty.

A laundry suite in a country or suburban house is a special set of offices consisting of a wash-house, a laundry, perhaps a hot drying-closet, and perhaps a closet for soiled linen, with a drying-ground attached. The whole group

ought to be kept well-separated from the bulk of the house for obvious reasons, with abundant light and air. The fittings are well known.

A linen-room is a small place amongst the bedrooms in which the stock of bed-linen may be kept, and perhaps table-linen for convenience. Dryness is here especially desirable, and the hot-water piping of a bath-room may be carried through it with advantage, even if it be only a cupboard.

A bath-room is now recognized as an indispensable supplementary in every house above a certain standard of moderate importance, and in larger houses several are required. Even in small suites of residential rooms such as are called "flats", and sometimes, indeed, in the ordinary bedroom-suites of family residences, a separate bath-room is provided. It is generally a small place, containing a reclining bath and little else; but if to be used by persons who must dress there, not only a wash-stand and a dressing-table, but a fireplace or gas-stove may be required. A water-closet ought to be accessible.

A lavatory is a wash-hand room for gentlemen, attached to the cloak-room of a good house, or very generally incorporated with it. It is simply provided with one or more wash-basins, towel and pin-rails, and a dressing-table; and the light must be duly considered. A water-closet is usually attached. The proper position is near the entrance-hall, so that visitors may have access to it; and a fireplace or a radiator is desirable in important cases, if only for drying damp garments. Fig. 11 represents a convenient arrangement.

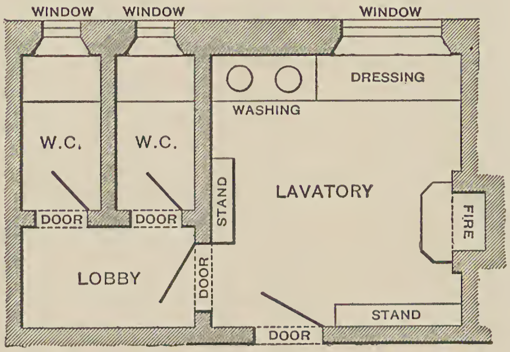


Fig. 11.—Lavatory and Closets.

The English **water-closet** with its sanitary apparatus is an institution of world-wide repute. The common faults of plan which have to be avoided are these:—It ought not to be insufficiently lighted, and certainly not inadequately ventilated; it ought not to be placed anywhere that may happen to offer, but invariably against an external wall; and especially ought the risk of flooding some important ceiling beneath to be avoided. Unquestionably the best plan is to place all water-closets, bath-rooms, housemaids' sinks, and wash and water places of every kind, one over another by themselves, so that in case of accident they shall only damage each other, and also so that the plumber shall be able to work his will without disturbing the house at large.

The question of the number of water-closets required for an average house

stands thus. In any case there will be one for the servants and one for the family. In larger houses one will be provided on the ground-floor for the use of gentlemen, and one or more for the bedrooms upstairs; then special ones for bedroom suites, nurseries, cloak-room, bath-rooms, billiard-room, school-room, business-room, and so on, as the establishment expands; and when the house is large enough, the servants of each sex have to be separately provided with a sufficiency properly distributed. The rules for position may be stated thus:—The English feeling of delicacy dictates privacy throughout, and therefore

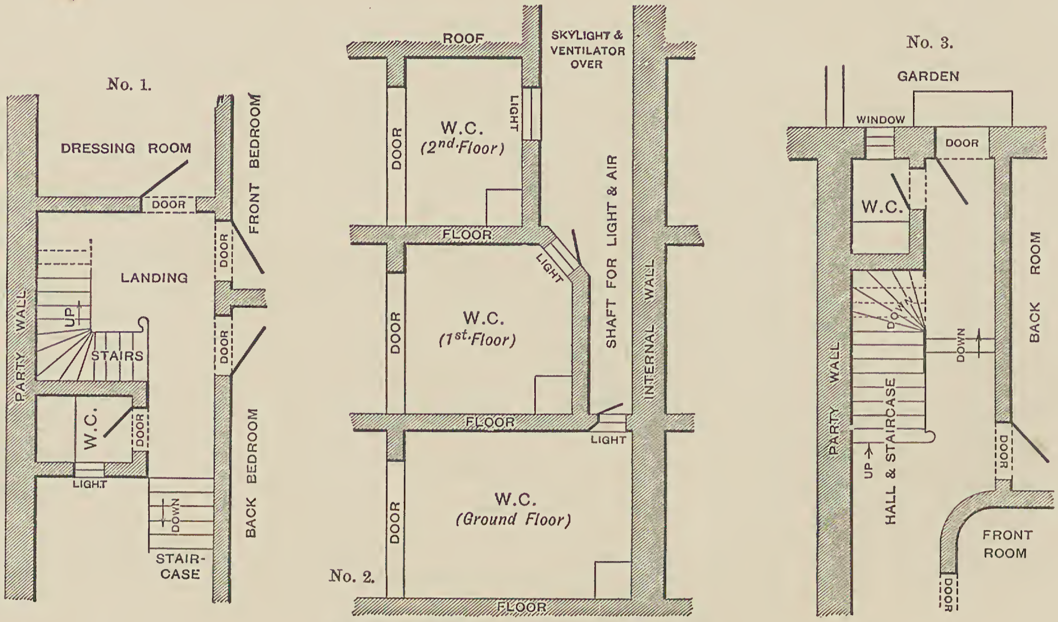


Fig. 12.—Internal Water-closets: Bad Examples.

the principal thoroughfares of the house must be avoided as much as possible; in every case there ought to be a window in an external wall; sky-lights are objectionable; well-holes or interior lighting-shafts are worse; and borrowed lights are not to be thought of.

No. 1, fig. 12, shows one form of an arrangement which still prevails in some of the highly-rented neighbourhoods of London; it is difficult to imagine a more objectionable make-shift. The staircase-landing adjoining the principal bedrooms is partly appropriated to the water-closet, which thus occupies a position in the very midst of the house; and the object of so placing it is to get a borrowed light (on hinges) towards the staircase as the nearest equivalent for the open air.

Another mistakenly ingenious plan is shown in No. 2. Several closets are

placed in the interior of the house one above another, and a small shaft is formed at the back, increasing in size to a sky-light in the roof, so as to afford such light and ventilation to them all as can be gained by means of small hinged sashes over the seats. The arrangements shown in Nos. 1 and 2 appear to have been devised in order to avoid occupying part of some external wall with the windows, which were considered an eyesore, but more modern planning gets over the difficulty in other ways.

The very common custom, in medium-sized houses, of putting a water-closet under the stair at the door which leads to the garden in the rear, shown in No. 3, is so objectionable in several respects that argument upon it is needless.

A coal-store is a necessary adjunct. In all houses except the smallest it is a good plan to have two stores, or one large store divided by a dwarf wall, so that two kinds of coal can be kept, one for the kitchen and one for the open fire-grates. In some cases provision is also made for the storage of coke. Rough shelves may be fixed in the coal-store for keeping firewood, or a separate **wood-store** may be built. A **boot-room** is required in large houses for the cleaning of boots, and may also be used for cleaning knives, or a separate room may be provided for this purpose. These rooms are often built along one or more sides of the kitchen yard, a covered way being provided for access.

The dust-bin or ash-pit may easily become a nuisance, and its precise situation is in most cases a matter for careful consideration. It ought to be far removed from all windows, and all that the designer of a plan can possibly do in the direction of avoiding air-pollution and facilitating cleanliness must be done. A covered and paved recess lined with glazed bricks and open in front, and of sufficient size to take the required number of galvanized-iron dust-bins, is a good arrangement.

SECTION I.—PLAN AND DESIGN.

PART II.

CHAPTER I.

HOUSES FOR LABOURERS AND ARTISANS.

The designing of small houses or cottages for the labouring classes is in some respects an easy matter; the rooms are few in number, the fittings are simple, and the construction presents no difficulties. On the other hand, if a reasonable interest is required on the outlay—and houses which do not "pay" cannot be regarded as entirely satisfactory from a politico-economical point of view,—it is necessary to study economy in every part of the building, and in many localities the financial question offers an almost insuperable difficulty. This is particularly true when the building regulations in force are unduly strict. Even in the First Garden City, at Letchworth, where the regulations are much less onerous than in many other districts, the problem of building a convenient family cottage for £150 has not been solved in an entirely satisfactory way. The higher rates of wages now paid, the increased prices of certain building materials, such as timber, and in many places the enhanced values of building land, have added to the difficulties of the problem.

The ideal house for an artisan family will contain, at the least, a living-room of ample size and three bedrooms, and the surroundings will be such that the rooms obtain a due measure of sunshine and fresh air. The houses themselves will not be crowded on the land, but each will have its plot of garden. That this ideal is also practicable has been proved by the association known as the Co-partnership Tenants. At Letchworth, Hampstead, and other places this association has built such houses to be let at fairly moderate rents, the number of houses being restricted to twelve per acre, and the venture is so far com-

mercially and hygienically successful. It must be confessed that these houses are beyond the means of many families, but the association is yet in its infancy, and the work already accomplished may be regarded as merely a beginning. Cheap houses will always be required for small and for poor families, and it is in the provision of healthy houses of this class that the greatest difficulty will be experienced.

Careful investigations have been made as to the heights, weights, and other physical characteristics, and also as to certain mental qualities, of school children in Edinburgh, Glasgow, Liverpool, and other cities and towns, and in some urban districts, and have shown conclusively that the children living in **one-roomed houses or tenements** are less fully developed than those living in larger houses. The stunted growth of the badly-housed children is in part due to the poverty of their parents, but there can be no doubt that the insanitary conditions of their home-life are in a great measure responsible. A family of normal size cannot be crowded into a single room without injury to the health and morals of the members of the family. In a room so crowded there can be neither comfort nor privacy.

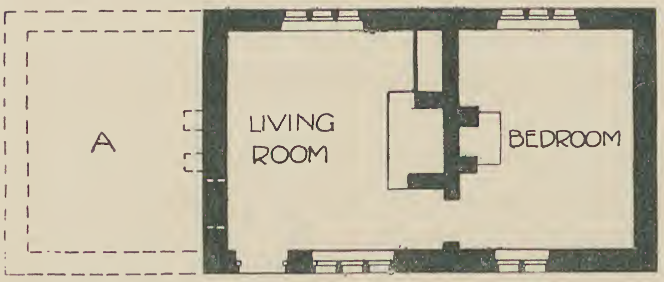


Fig. 13.—Old Plan of Two-roomed and Three-roomed Cottage.

In its simplest form the cottage is little more than a shell with four walls and a roof, enclosing a single room, which serves as a general living-room by day and a general bedroom by night. Hundreds of these "cabins"—to our disgrace be it said—are still to be found in Ireland, and they are not unknown in some parts of Great Britain. The floors are often of clay, the walls of rough stone, and the ceilings open to the thatch or other roof-covering, and usually there is neither water-supply nor sink. Such cabins are shelters rather than houses. The addition of a second room, as in fig. 13, is a great improvement, but even in this case the evils of overcrowding remain, although to a less degree. The second room in old cottages was usually built at one side of the living-room, one chimney serving the two rooms, and when a third room was added, as at A in fig. 13, it was often placed on the other side, thus completing a simple plan in which each room could have windows or doors on two opposite walls with all the advantages of sunlight and through-ventilation. Such a plan requires a wide frontage of land for each house, and for this reason, and also

because the quantities of external walling and of roof are large in proportion to the space enclosed, it is now seldom adopted.

In many old houses a bedroom was formed in the roof, and although this room was usually too low to be either convenient or healthy, it was an economical method of increasing the accommodation of the house. The general arrangement is good, as, whether the houses are detached or in rows, each room can have windows on both sides with the advantage of through-ventilation, and

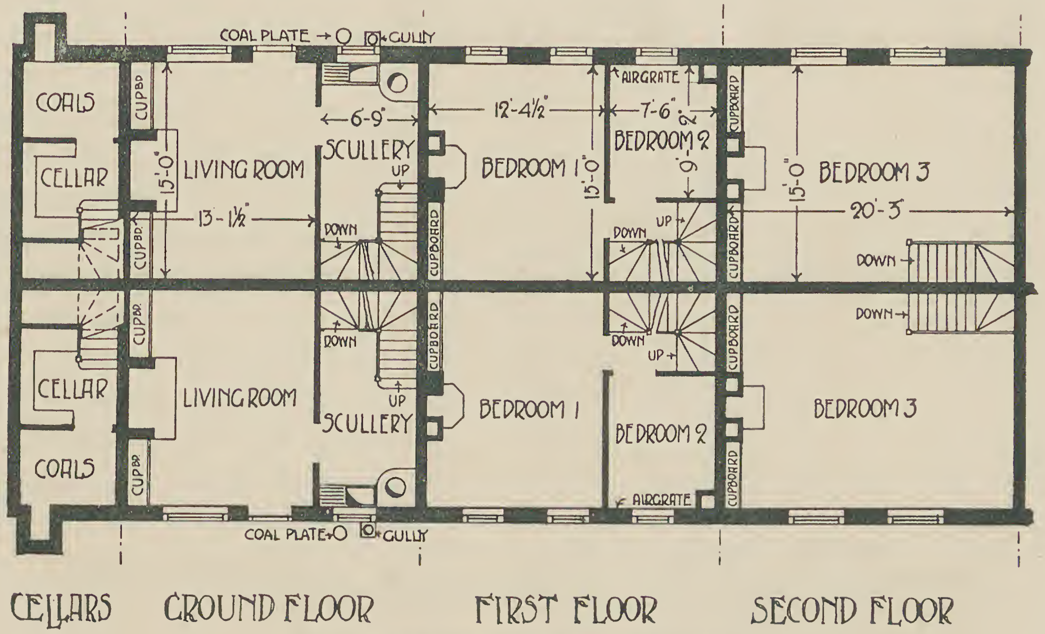


Fig. 14.—Back-to-back Houses (seriously defective).

the principal windows can be placed in that side which has the more sunny aspect.

In some towns this plan has been duplicated to form what are known as **back-to-back houses** (fig. 14). The only point in favour of these houses is that they can be cheaply built; among their defects are the lack of through-ventilation, the absence of any yard, and the grouping of the closets at one or both ends of the block of houses.

The two plans in fig. 15 have the living-room and scullery one behind the other, and are given as interesting examples of "**through-houses**" built in the same village and on the same side of the road about 150 years ago. The road runs along the north side of the two rows of houses, and the only difference in the plans is that in the one case the living-rooms overlook the road and have therefore a north aspect, while in the other they have a south aspect and over-

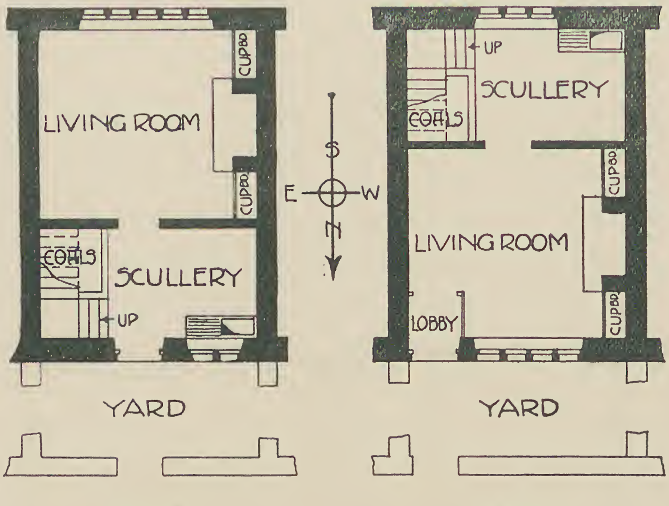


Fig. 15.—Two Varieties of Old Houses in Rows.

look the field in the rear. In each case there was originally one large room upstairs, which was used for hand-loom weaving by day and as a bedroom by night; but in some of the houses this has been divided into two bedrooms at a later date. These plans are interesting also as being early types of the thousands of houses which have been and still are being built, particularly in manufacturing towns. A common arrangement (fig. 16) has a living-room of

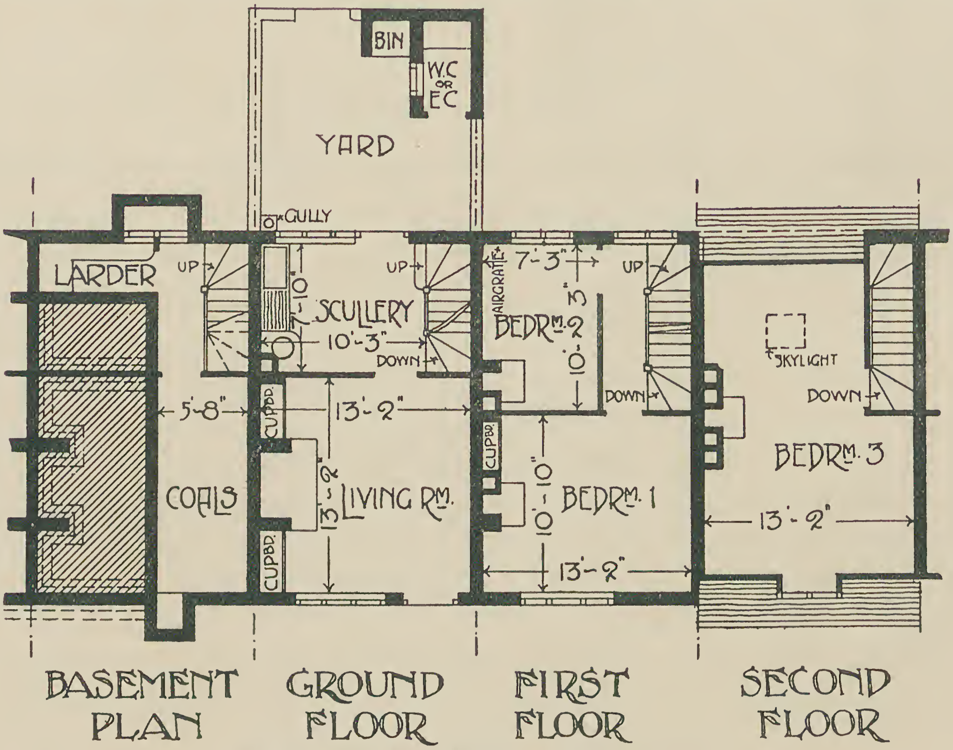


Fig. 16.—Ordinary Urban Five-roomed House for Artisans.

good size in front, entered directly from the street or from a very small strip of garden, a "kitchen" in the rear with a back door to a yard, from which a

gate leads to a public back passage of sufficient width for carts; on the first floor there are two bedrooms, and on the second floor there is a third bedroom in the roof, separate sleeping accommodation being thus provided for the parents and for children of both sexes; the coal-place and larder are usually in the basement, and the privy or closet in the back yard.

The persistence of this type of house is presumptive evidence that it is suitable for artisans both as regards accommodation and rent. From the artistic point of view, however, it leaves much to be desired. **Long rows of these houses** are very monotonous and depressing, and the houses are usually built on such small plots of ground that there is absolutely no possibility of relieving or masking their ugliness by growing trees near them, and in many cases there is not even space for a shrub or a plant; the back passages and the yards with their small outbuildings are also most unsightly, and in many cases insanitary. Fig. 17 shows the arrangement approved by the by-laws in many districts, forty or fifty houses being crowded on each acre of land. In some cases the streets must be 40 feet or more in width, but every foot must be paved. It is difficult to imagine anything uglier than the straight streets and long rows of similar houses in working-class areas. The wonder is not that the movement in favour of Garden Cities and Garden Suburbs is making headway, but that it has been so long delayed.

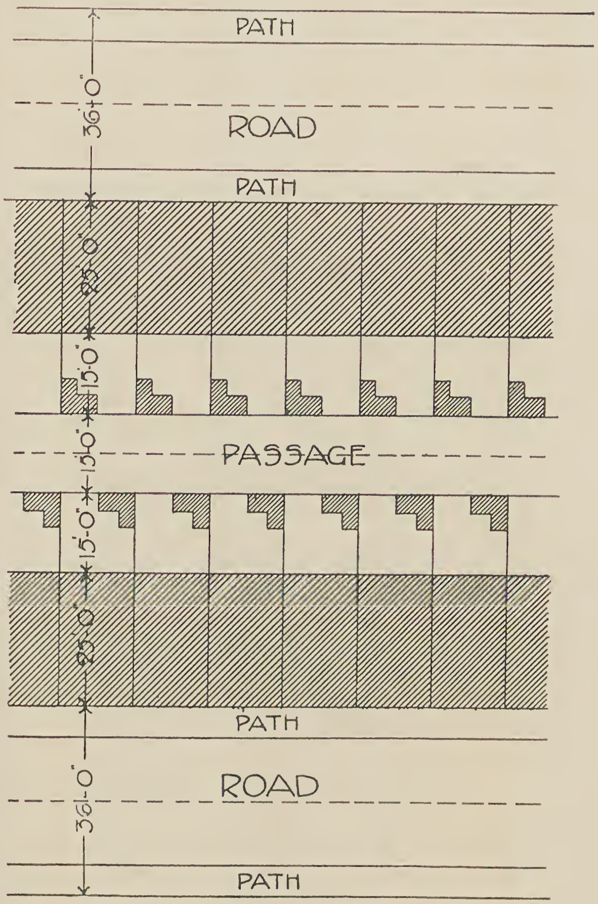


Fig. 17.—Streets and Houses in Working-class Area.

In some cases the room in the rear is enlarged and converted into the living-room, the front room becoming **a parlour or sitting-room.** The upper floors may be the same as in fig. 16, but larger, or three rooms may be obtained on the first

floor as shown in fig. 18, the second floor being then omitted. Such a house is suitable for the more-highly-paid artisans and for families in which there are two or more persons in receipt of fairly good wages. Houses of this kind are almost invariably planned without any regard to aspect: the front room is the sitting-room, and the back room the living-room, and, unless the roads run nearly due

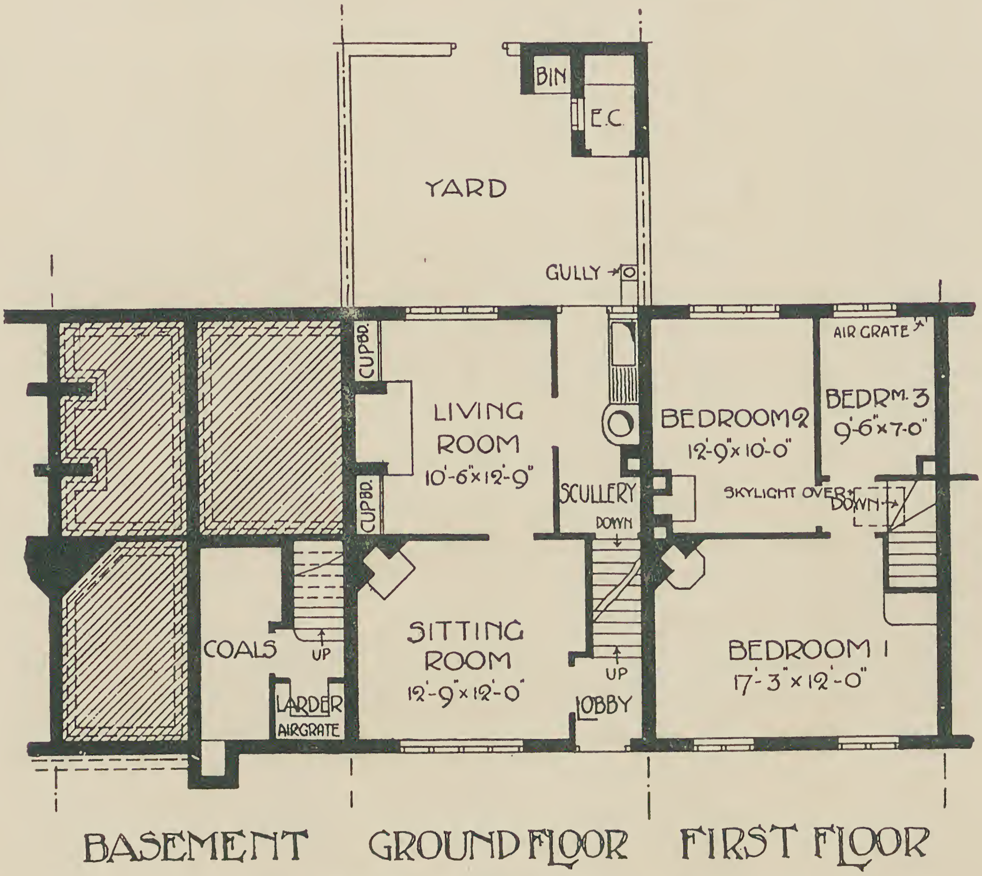


Fig. 18.—House with Living-room, Sitting-room, Scullery, and Three Bedrooms.

north and south, one of the rooms will be without sunshine for the greater part of the year.

In the modification shown in fig. 18 a scullery is provided at one side of the living-room, but the coals and larder remain in the basement.

The stairs in small houses present some difficulty. In fig. 16 they ascend from the scullery, and on the whole this is the best arrangement, as waste water from the bedrooms can be taken to the yard gully without having to be carried through the living-room. In fig. 18 the foot of the stairs is close to the front door, and, although this is convenient for visitors, it has the disadvantages of

converting the sitting-room into a passage from the living-room to the bedrooms, and of causing the waste water from the bedrooms to be carried through the sitting-room and living-room.

An improved plan is shown in fig. 19. The same arrangement of stairs is adopted as in fig. 18, but if the partition indicated by dotted lines is constructed

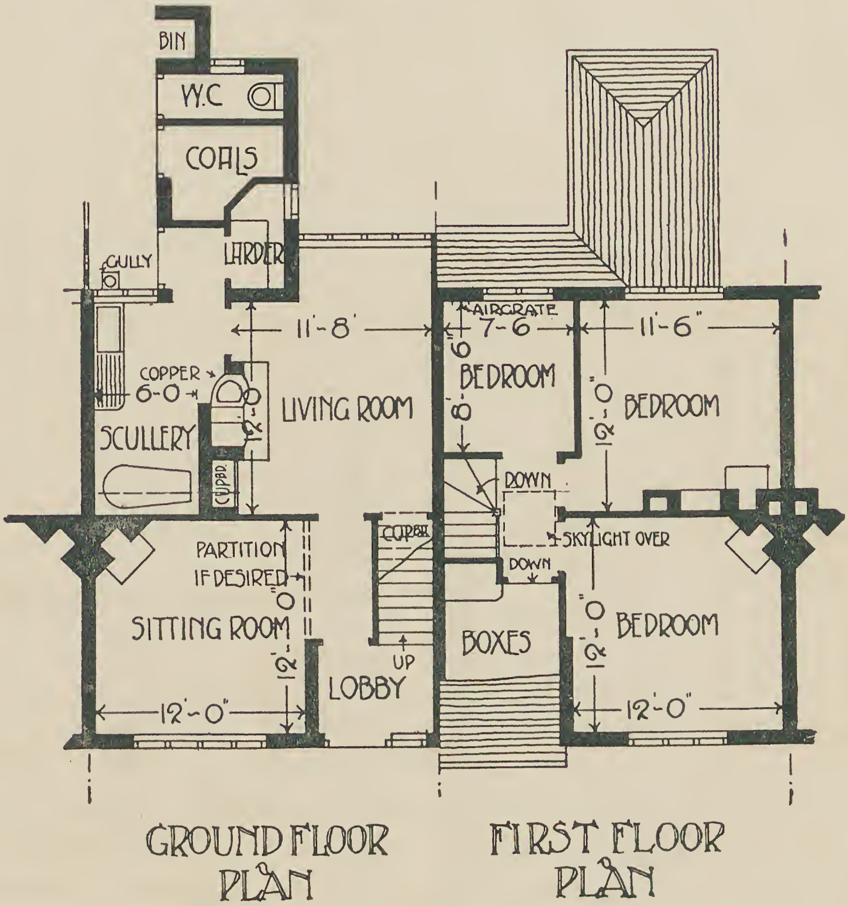


Fig. 19.—Six-roomed House with Bath.

the sitting room ceases to be a passage. In this plan the coals and larder are more conveniently placed on the ground-floor, and the scullery is behind the living-room range and is fitted with a bath to which hot water from the range boiler or copper can be laid on. Special ranges are now made for the purpose, with coppers at a high level, approached from the back of the range, but heated by the range fire. The alternate houses are reversed, so that a fairly-wide space is left in the rear of the living-rooms. On the first floor there are three bed-rooms and a box-room, the last having a small skylight. Another skylight

is provided over the landing. The plan lends itself to a simple but effective architectural treatment, each of the front bedrooms being gabled and the main roof sloping down over the box-rooms to about the level of the first floor.

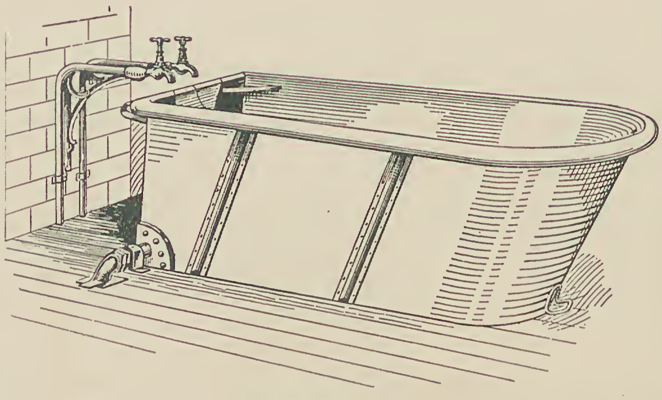


Fig. 20.—Tip-up Bath.

The importance of providing **a fitted bath** in artisans' houses is now recognized by all sanitarians, and much ingenuity has been shown in designing combinations of baths, sinks, and coppers which will occupy little space and be economical in first cost and in maintenance. In some cases the bath can be turned horizontally (like a gate) under the sink and drainer when not in use, and in others it can be turned up into a cupboard. The arrangement shown in fig. 20 is of the latter kind. The bath is of sheet metal, and the waste-outlet has a bent swivel-union, which allows the bath to be turned up or down.

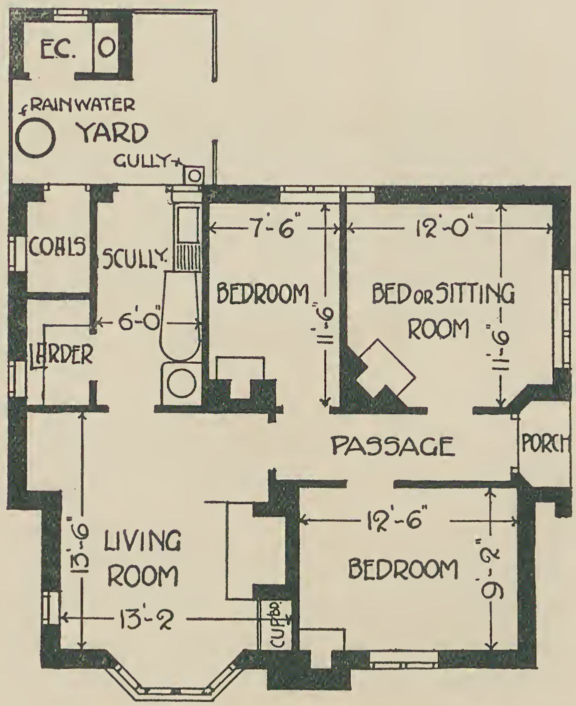


Fig. 21.—Gardener's Detached Cottage of One Story.

Detached houses of these classes are seldom built with a view to obtaining a profitable rental, but as they are required for the accommodation of gardeners, coachmen, and others, on private estates, an example may be useful. In many cases, men-servants with children, or with more than one or two, are objected to, and the bedroom accommodation provided is purposely less than that required in the normal house. Fig. 21 is the plan of a detached cottage of one story, built from the writer's design as the gardener's lodge at the entrance gates of a

country house. A bath is provided in the scullery, and cold water is laid on to it, but hot water must be drawn by hand from the range boiler. A small loft, approached through a trap-door, is constructed over the scullery, and serves as a box-room. A view of the exterior is given in No. 4, Plate XXVII. The plans of a coachman's cottage, built over a coach-house, are given in fig. 729, page 453, Vol. II., and a view of the building in Plate XXVII. The gardener and coachman employed at the time these cottages were built were married but without children. Another gardener's cottage is shown in fig. 33.

Semi-detached houses can be built a little more cheaply than detached houses, and, as they are equally healthy, and have as pleasing an appearance, they are

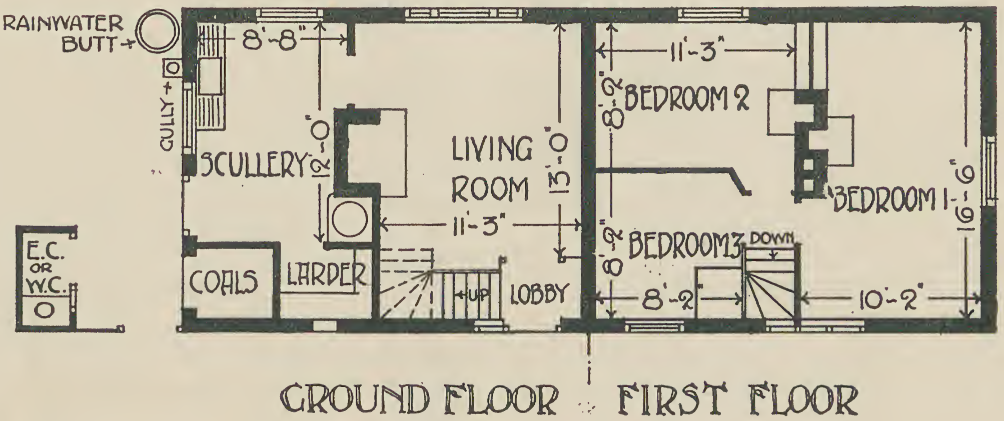


Fig. 22.—Pair of Farm-labourers' Cottages.

more often required. The example given in fig. 22 is slightly modified from a pair of farm-labourers' cottages built from the writer's designs. The road is on the north side of the houses, and the living-rooms are therefore placed in the rear, and have an unobstructed view over the gardens attached to the houses and over the fields beyond. The accommodation on the ground floor comprised a living-room, a large scullery with copper, a larder and a coal place, and each house has a detached w.c. Three bedrooms are provided on the first floor.

The pair shown in fig. 23 is on a larger scale, but the principal entrances are again on the north side. The sitting-room has a pair of French doors opening to the garden in the rear, and the living-room also has a south aspect. The kitchen or scullery has a copper and sink, and a bath may be fitted under them. In the entrance passage the space under the stairs may be enclosed to form a store cupboard, or left open to accommodate a perambulator or one or two cycles. Three bedrooms of good size are shown on the first floor. The

external walls are of 9-inch brickwork, finished with cement roughcast, and the roofs are tiled.

A block of four houses for a corner site, with gardens in front and in rear,

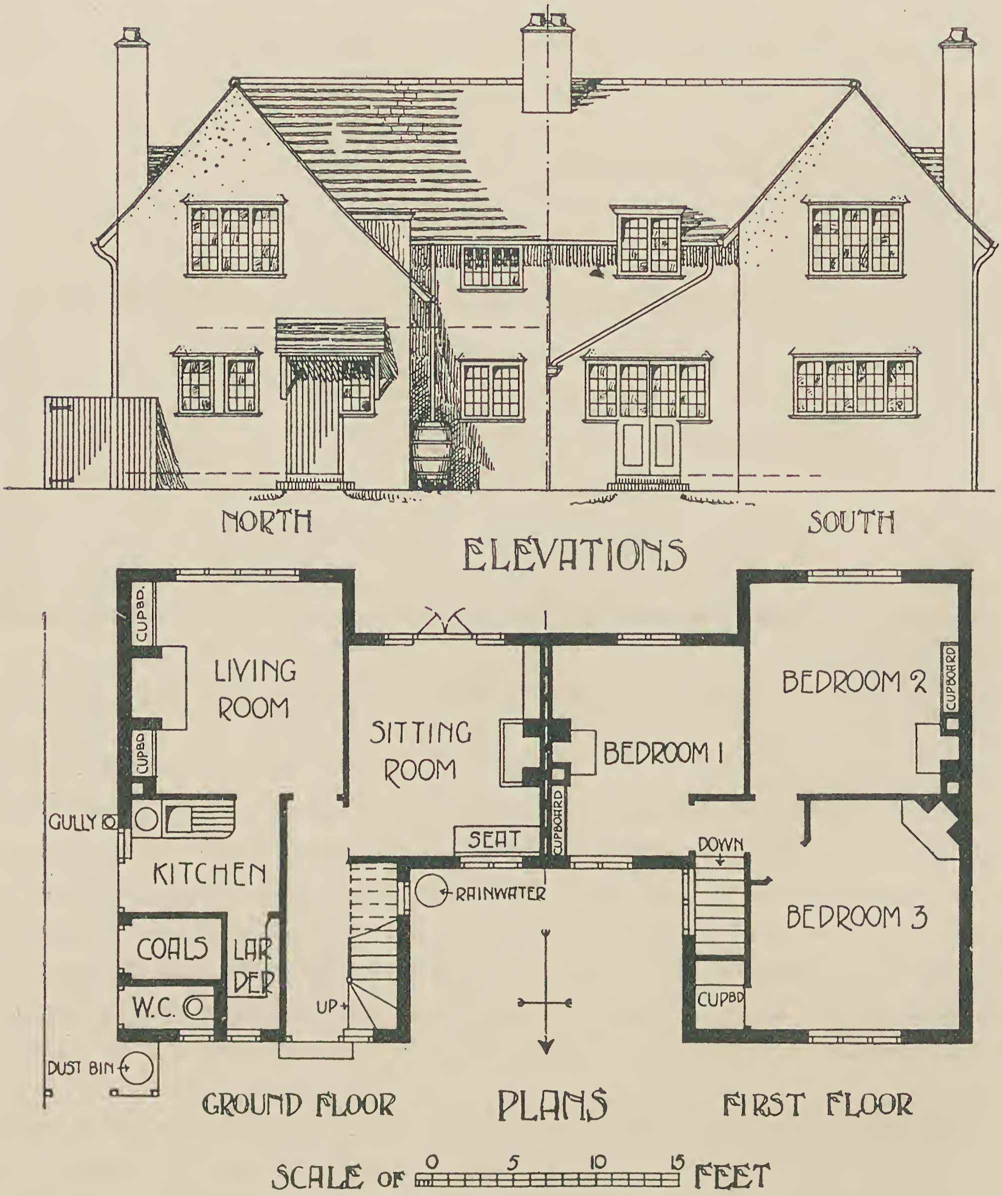
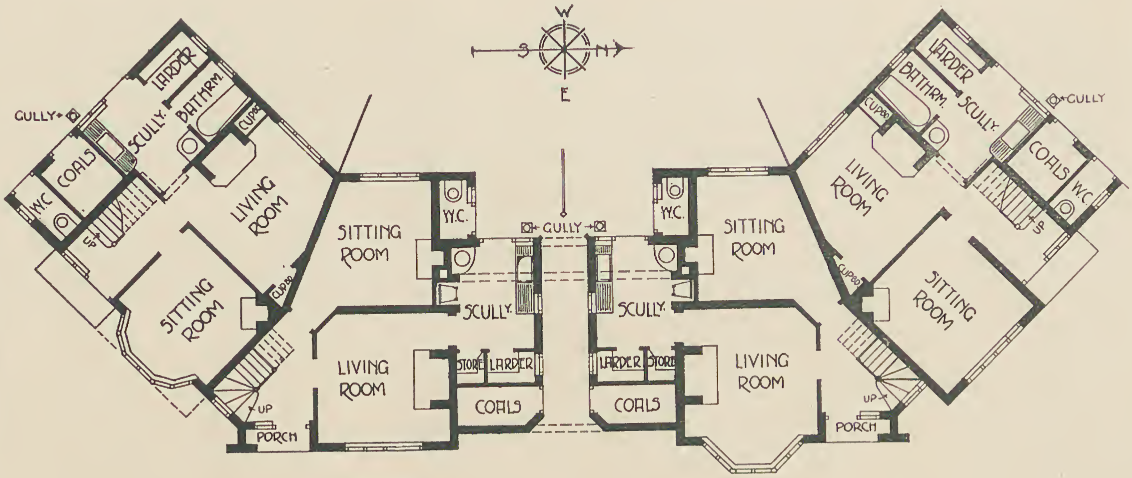


Fig. 23.—Pair of Six-roomed Cottages.

is shown in Plate IA. The four houses differ somewhat both in plan and elevation, but have almost exactly the same accommodation—namely, sitting-room, living-room, scullery, three bedrooms, and the usual offices. Each of the



GROUND FLOOR PLAN

SCALE OF FEET
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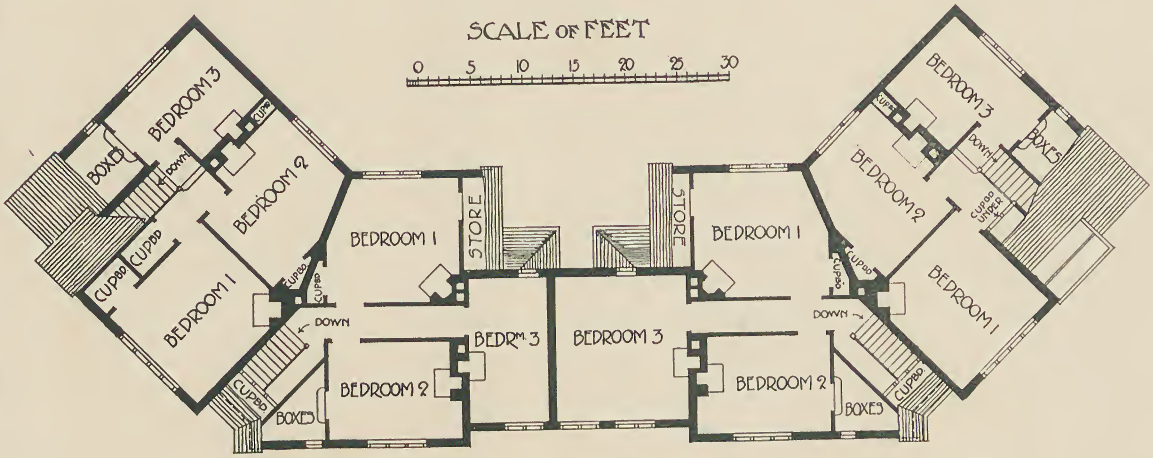
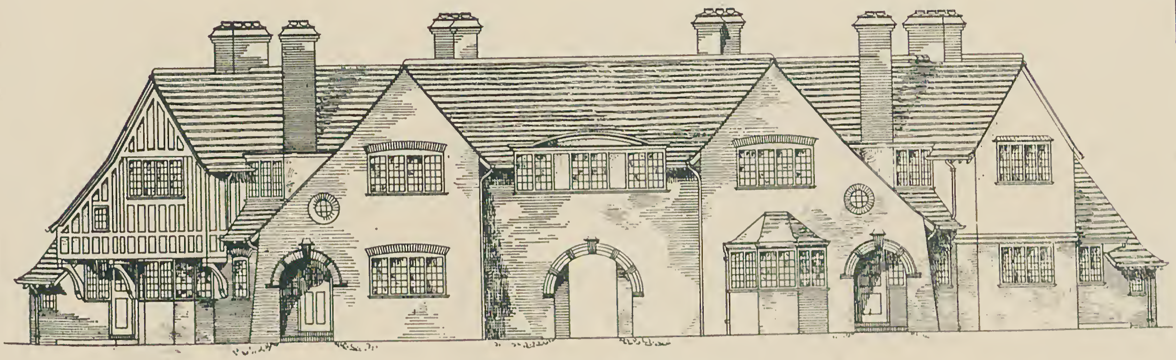


FIRST FLOOR PLAN



FRONT ELEVATION

GROUP OF FOUR HOUSES FOR A CORNER SITE.

two middle houses has a tip-up bath in the scullery, and each end house has a small bath-room entered from the scullery. The central passage on the ground floor affords access to the back doors and gardens in the rear of the middle houses. Externally the houses are differently treated, the two middle houses and the lower stories of the other houses being faced with bricks, and the upper portions of the end houses being of half-timber work with cement panels in the one case, and of brick finished with cement roughcast in the other. A group of houses of this kind is suitable for a conspicuous site in a Garden Suburb.

A separate wash-kitchen has not been shown in any of the plans, although it is highly appreciated by tenants. Sometimes one wash-kitchen is provided for two or more houses, but this arrangement does not meet with much favour. If a separate wash-kitchen for each house cannot be afforded, a compromise is sometimes effected by constructing a kind of verandah or large porch (properly paved and drained) outside the scullery door, so that the washing can be done under cover and within easy reach of the copper and hot water. By this arrangement, which can be easily adopted in the two middle houses shown in Plate Iᴀ, the unpleasant smell and moisture are in a large measure kept out of the house.

A tool and cycle shed is also useful, especially in a Garden Suburb or Model Village, where every house has its plot of garden.

Although the number of rooms required in an artisans' house is so small, **the possible combinations** are almost endless, and it is impossible in a work of this kind to deal fully with the subject. The examples given may, however, be of use in showing how great the difference may be both in plan and in external treatment.

Some details of planning and construction must now be mentioned. Where *pail-closets* are used, they must be detached from the main buildings. Many by-laws specify that they must be at the least 6 feet away from any house, but this distance is insufficient, and there can be no doubt that at the best such closets are objectionable, and in many cases they are a positive danger to health. *Earth-closets*, if properly constructed and attended to, are much better, and in many districts they may be attached to houses if they are provided with adequate means of lighting and ventilation. In such cases the floors and walls ought to be cemented or covered with other impervious material. It often happens, however, that earth-closets prove a nuisance, either because the supply of dry earth is not maintained, or because the receptacles leak or are not emptied often enough, and it is therefore much better that they should not be connected to the houses. *Water-closets* flushed with clean water (not with waste water from the

sinks) are better on the whole than earth-closets, and have the additional advantage of doing away with the small outbuildings which are such an unsightly feature in the rear of so many rows of workmen's houses. Of course, every water-closet apartment must have a window made to open, and it is a good plan to have the door in the open air, as in figs. 19 and 23, or in an open porch.

Small bedrooms without fireplaces ought to be provided with some means of ventilation in addition to the window and door. As a rule, by-laws require an air-grate in the external wall, as shown in figs. 16, 18, and 19.

Some by-laws, especially those in force in large towns, insist on the *party-walls of houses* being carried above the roof to a height of 12 or 18 inches. This certainly has the advantage of checking the spread of fire, but it is not often required in rural and small urban districts, and has therefore not been shown in the elevations given in fig. 23 and Plate Ia.

Local by-laws usually specify that *the external and party walls* must be built of incombustible materials, and that incombustible materials must also be used for roof-coverings. The thicknesses of walls of different lengths and heights are also prescribed in certain by-laws. Although much can be said in favour of these restrictions, there can be no doubt that they have tended to stereotype old methods of construction, and have prevented the adoption of new methods. It is possible to build a wall of thin concrete or other blocks which will be as serviceable as a 9-inch brick wall, but if the by-laws require a thickness of 9 inches, the thin blocks cannot be used. The importance of economy in the building of small houses can scarcely be overestimated, and in the case of detached houses there does not appear to be any valid reason why incombustible materials of a certain thickness should be insisted on. If a sound and weather-tight building can be constructed in some other way, permission ought not to be withheld. In the case of semi-detached houses, or even in terrace-houses, the external walls may be freed from some of the restrictions now in force, if the party-walls are properly constructed.

CHAPTER II.

COUNTRY HOUSES.

Country houses containing not more than two sitting-rooms will be first considered. Of these there are **two principal varieties**, namely, those intended for regular occupation, and those which are often known as "week-end cottages". In each variety there may be houses of one story, to which the name "bungalow"[1] is properly applied, and houses of two or more stories. One of the first questions to be decided before planning a house is that of the number of stories.

Bungalows, in which all the rooms are on one floor, are most suitable for week-end cottages with small accommodation, but may also be built on a larger scale in open situations. They cannot be recommended for low-lying sites or for sites where there are large trees near the house, as the night air at the level of ground-floor rooms is often more damp and still than at a higher level. Another objection to ground-floor bedrooms is that, through fear of burglars, windows may be kept closed at night, and the rooms may thus be inadequately ventilated at the time when ventilation is most necessary. The question of privacy both by day and night must also be considered. As regards cost, it may be said that a two-storied house is almost invariably cheaper than a one-storied house containing the same accommodation. On the other hand, the absence of stairs is an advantage, and in exposed situations the weather has less effect on a bungalow than on a loftier house.

The prevailing note is usually that of simplicity. As they are occupied mainly during the summer months, the accommodation is restricted to that required by persons living for the time as much as possible in the open air. One large living-room may suffice for the use of the family during the day, and a small kitchen for the servant or servants. A verandah with a sunny aspect is, however, almost indispensable, and will be all the more useful if it is built of such a shape and size that meals can be served in it. The bedrooms are usually smaller, and the offices fewer and simpler, than those in a permanent home; but, however simple the accommodation may be, a bathroom cannot well be omitted. Fig. 24 is an example of an unpretentious bungalow containing a large living-room, a verandah of good size, four bedrooms, a kitchen, and the usual offices. The servant's bedroom is near the kitchen, and quite apart from the other bedrooms, which are placed in a separate wing together with the

[1] The name is also sometimes given to houses with an upper story in the roof.

bathroom and water-closet, and are entered from a passage leading from the garden entrance and communicating also with the living-room.

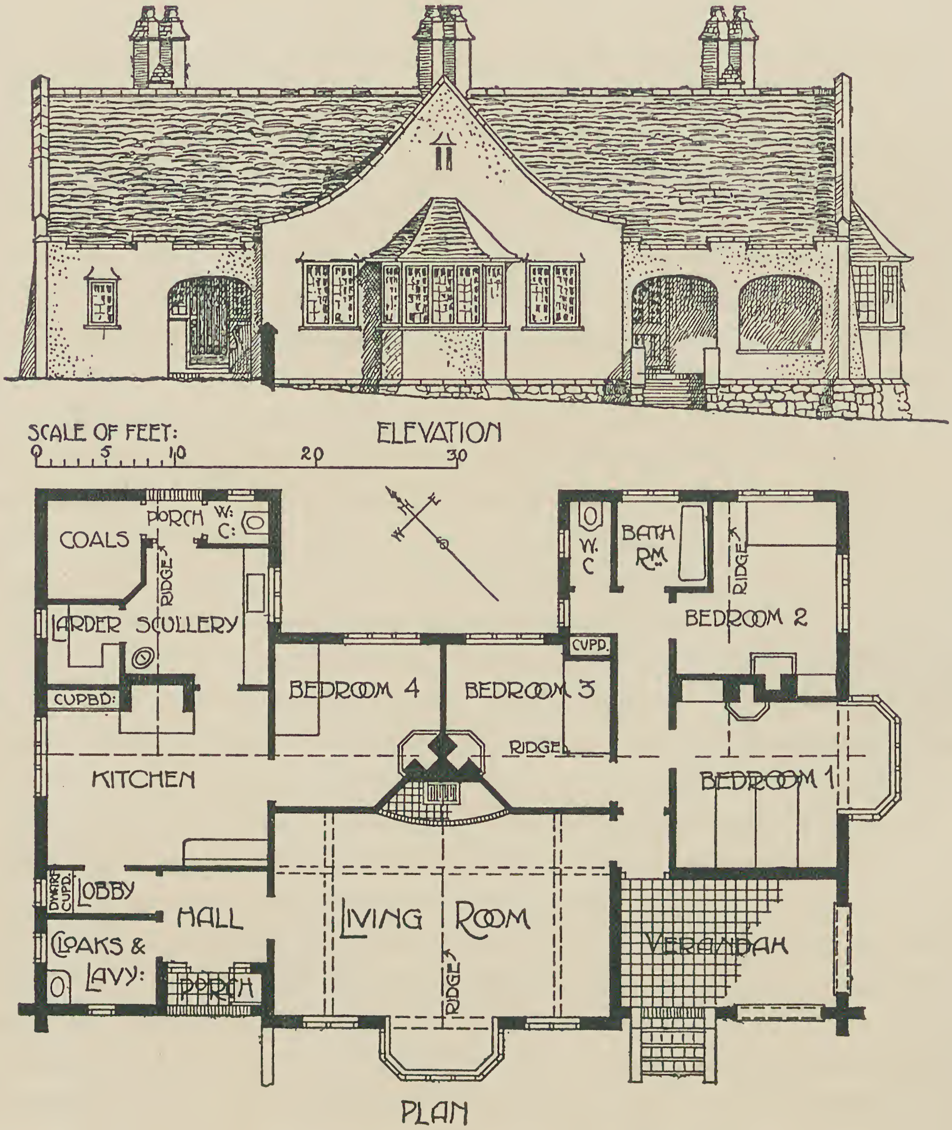


Fig. 24.—Bungalow with Living-room and Four Bedrooms

Houses of two stories are on the whole the most suitable, especially for regular occupation. They are almost as convenient as bungalows, and have fewer disadvantages. A house with a third story in the roof may be cheaper to build, but unless it is skilfully designed it will have the objectionable appearance of a suburban villa. Basement rooms, other than cellars, are quite out

No. 1

No. 2

No. 3

BEDROOMS

No. 1. WITH SLOPING CEILING; No. 2. WITH ARCHED CEILING; No. 3. WITH FITMENT.

of place. A house which is long in proportion to its height is more appropriate for the country than a short and lofty house.

Rooms in the Roof.—Two or three feet can be saved in the height of the building by running the bedrooms up into the roof, as shown in fig. 23 and Plates IA, IB, and IC. If the lowest part of the roof-slopes is 7 feet from the floor, an ordinary wardrobe can be placed against any blank wall, and a picture-rail can be fixed around the room at the convenient height of 7 feet and continued over the doorways as a cornice. The ceilings, in ordinary cases, will consist of a central flat portion and a slope on each side, as shown in No. 1, Plate IB, but an excellent effect, at a little extra cost, can be obtained by arching the ceiling as in No. 2. The less important bedrooms may have lower side-walls, but many by-laws do not allow the height to be less than 5 feet, and at the same time insist on a certain proportion of the area of the room (say, two-thirds or three-fourths) being not less than 8 feet high. In many rooms the lower parts of the roof-slopes may be concealed by hanging cupboards or other fitments. No. 3, Plate IB, is an example of a fitment occupying the whole of one side of such a room. It has a central dwarf cupboard serving as a toilet-stand, the recess above the cupboard being covered with enamelled zinc known as "Emdeca". On one side there is a wardrobe, and on the other a chest of drawers with a small cupboard over it.

The accommodation required in these houses may be no more than that contained in some of the workmen's houses illustrated in the previous chapter, but, as a rule, the domestic arrangements are different, and these necessitate some differences in the plan. For example, one or more servants may be employed in the house, and separate meals must be served for them and for the family. The living-room of the workman's house is therefore converted into a kitchen, which serves for the cooking of all the food, and also as a dining- and sitting-room for the maid or maids. Another room is required as a family dining-room, and, in addition to this, there is usually either a large hall furnished as a sitting-room, or a separate apartment which is variously described as a drawing-room, sitting-room, or parlour. The quantity of glass and china required in such a household will be larger than that required by a workman's family, and extra provision must be made for its storage and washing. This usually takes the form of a maid's pantry fitted with a sink and one or more cupboards. In a small house the pantry may be placed between the hall and the kitchen, and will then be in a convenient position for the use of the lady of the house in arranging flowers, washing fragile china, &c. while at the same time it will in some measure prevent the smell of cooking

from pervading the house. The larder and other domestic offices must also be on a larger scale than in an artisan's house, and a separate bathroom on the bedroom floor will almost certainly be required. As a general rule, also, two water-closets must be provided, one near the external door to the kitchen department (fig. 26), for the use of the servants, and one near the bedrooms, for the use of the family. Sometimes the latter is reserved for ladies and children, and a third is provided, on the ground floor, for men, privacy being obtained by planning it as an annex to a cloakroom or lavatory, as shown in fig. 31, and in Plates Ic and XXVIII. On the bedroom floor a small room for use as a dressing-room may be required in connection with one of the bedrooms, and a linen-closet and box-room will also be necessary. In houses intended for permanent occupation, a room with a sunny aspect may have to be set apart for use as a day-nursery, and perhaps another as a night-nursery. A sink with hot and cold water laid on is often fixed in a small closet near the nurseries.

In houses of the class under consideration a supply of hot water is almost invariably required, the principal exceptions being small week-end cottages in the construction of which economy has been carefully studied. The hot water is laid on to the sinks, lavatory basins, and bath, and perhaps to a draw-off near the bedrooms, and it is a good plan to warm the linen-closet by running the hot pipe through it, or by fixing the hot cylinder or tank in it.

The arrangement of the rooms must be governed mainly by the aspect of the house and the position of the road. Prospect and privacy must also be taken into consideration. Taking as an example the common square house shown in No. 1, fig. 25, we find that it is not suitable for any site except one approached from a southerly direction, and even for this it is far from satisfactory. The dining- and drawing-rooms have their principal windows on the same front of the house, and the main entrance is between them. Anyone approaching the house must pass through that part of the garden which is overlooked from the windows of the two rooms, and this arrangement is certainly not the best. A more private garden and lawn can, it is true, be formed on the west side of the house, and if a window is placed in the west wall of the drawing-room, the prospect over the garden will be a pleasant feature. A better plan can, however, be obtained by placing the main entrance in one side of the house, as shown in No. 2, as with this arrangement the principal windows of the two rooms and the garden in front of them can be screened by shrubs from the entrance path or drive. In each of these two plans the dining-room is placed in the south-east corner of the house, and the drawing-room in the south-

west, so that by means of side windows the former will have the benefit of the morning sun, and the latter of the evening sun.

If the house is approached from the east, plan No. 2 is clearly better than No. 1. For a site approached from the west, No. 2 may be reversed, or one

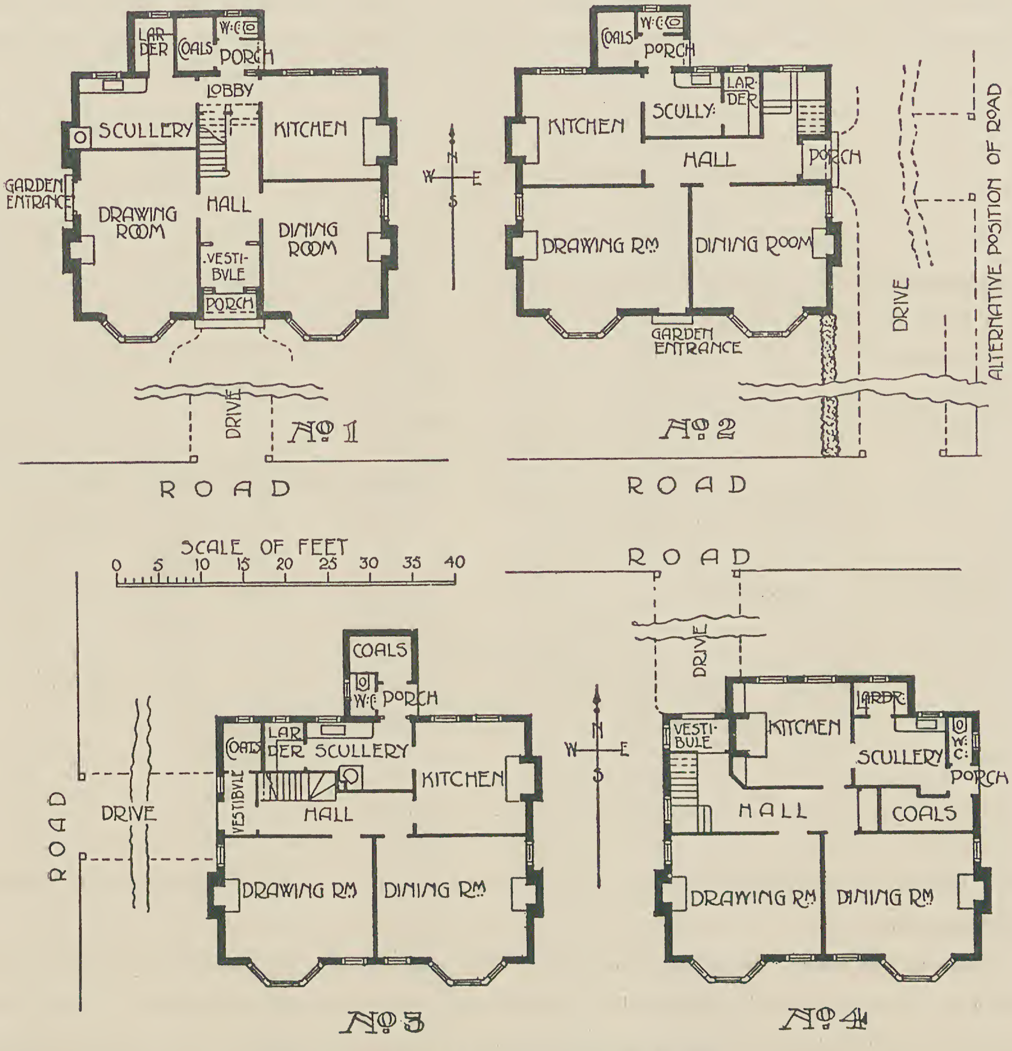


Fig. 25.—Typical Square Plan varied to suit different Sites

of many variants, such as No. 3, may be adopted, the kitchen in this case being conveniently placed behind the dining-room. If the road is on the north, No. 1 is quite unsuitable; Nos. 2 and 3 are better, but the best plan in many cases will be one with the main entrance on the north side, as shown in No. 4, as by this arrangement privacy can be obtained for the gardens on the other three sides of the house.

These plans are given not as examples of good or interesting design, but merely to show the importance of giving due consideration to the question of aspect. In many suburbs, and even in some rural districts, houses of the kind shown in No. 1 have been built with the entrance and the two sitting-rooms facing the main road, whether this has been to the north, south, east, or west of the house. The sitting-rooms in many of the houses are almost sunless,

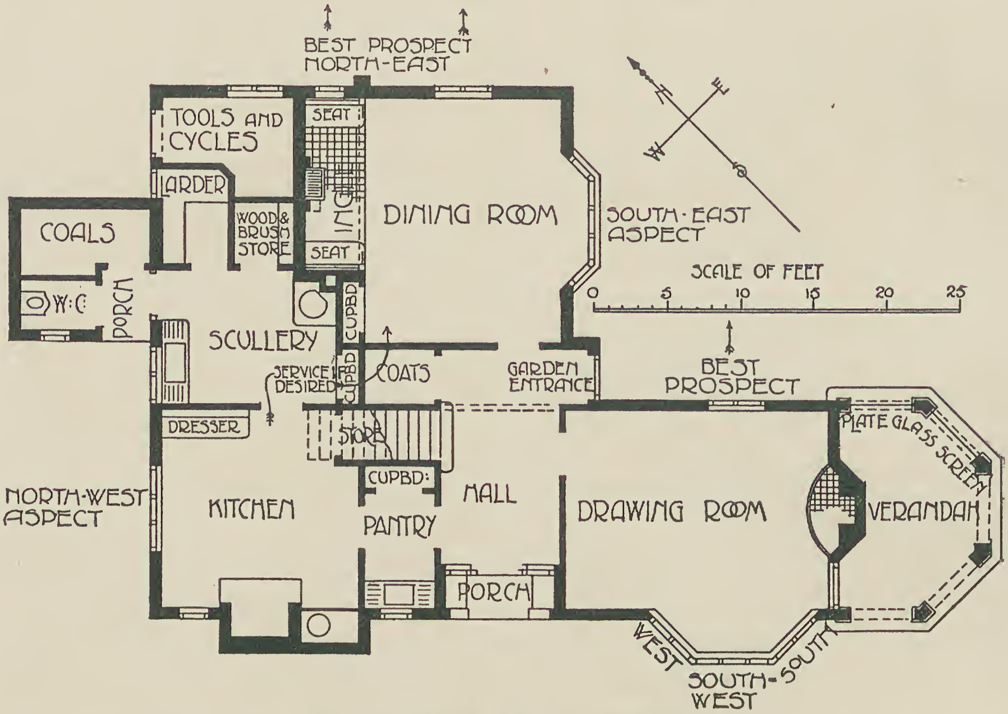


Fig. 26.—House planned for Aspect and Prospect

and the kitchen, which ought to be in a cool position, is in summer too sunny for comfort.

The question of prospect must also be considered. If the best prospect and the best aspect coincide, there is no difficulty, but when this is not the case the problem of designing the house is not such an easy matter. A solution may sometimes be found in having windows on one side of the room for a sunny aspect, and on the other for the best prospect. In other cases it may be necessary to plan one room for aspect and the other for both aspect and prospect. In fig. 26 the former solution has been adopted. The best prospect is to the north-east, and the most convenient approach is from the south-west. The dining-room is placed on the north-east side of the house, with small windows commanding the best prospect, and with a bay window on the south-

east side overlooking the garden and obtaining all the morning sunshine. The drawing-room has a small north-east window and a large south-west bay, the latter receiving all the afternoon sunshine. As shown in the illustration, a French window or doorway can be formed in the south-east wall of the drawing-room for access to a sunny verandah, which can be sheltered from the north-east by sheets of plate glass without obstructing the view. As an alternative a conservatory may be built instead of the verandah. If objection is taken to the windows directly opposite to each other in the drawing-room, the bay

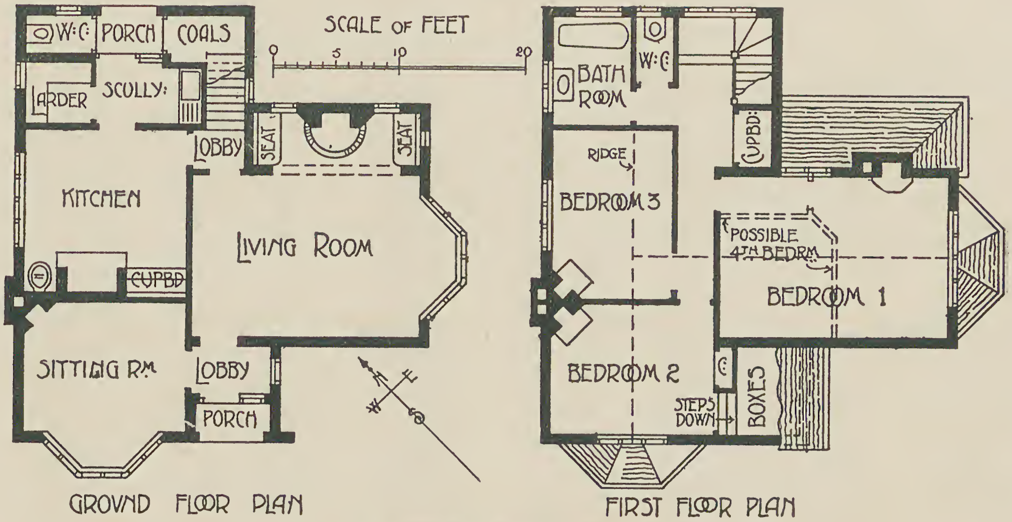


Fig. 27.—House with large Hall and Sitting-room

and fireplace may be transposed, and a small window may be placed in the south-west side between the fireplace and the porch.

The small window on the south-west side of the kitchen will be a pleasant feature in winter, but the principal window is on the north-west side, so that the room will not be unpleasantly hot in summer. The offices are more complete than is usually the case in houses of this class.

On the first floor there are five bedrooms. The bathroom and water-closet are placed over the scullery to simplify the plumbing and drainage, and a linen-closet is provided, with a hot-water pipe carried through it.

Two or three examples of houses will now be given, but it is of course impossible to do more than indicate a few of the almost innumerable varieties of plan and design. Fig. 27 shows a compact little house with a small sitting-room and a fairly large hall or living-room. As a rule a hall of this kind is used for meals, and the other room is used as a drawing-room. The arrangement has certain obvious disadvantages, but in the example given these are

in some measure obviated by planning the sitting-room so that it is entered from the entrance lobby and not from the hall. This plan would, however, be inconvenient if the sitting-room were to be used for meals, unless a service-door or hatch were made for direct communication with the kitchen.

A larger house with two sitting-rooms and a hall is shown in fig. 28 and No. 2, Plate IF. In this case the road is on the north side, the main entrance

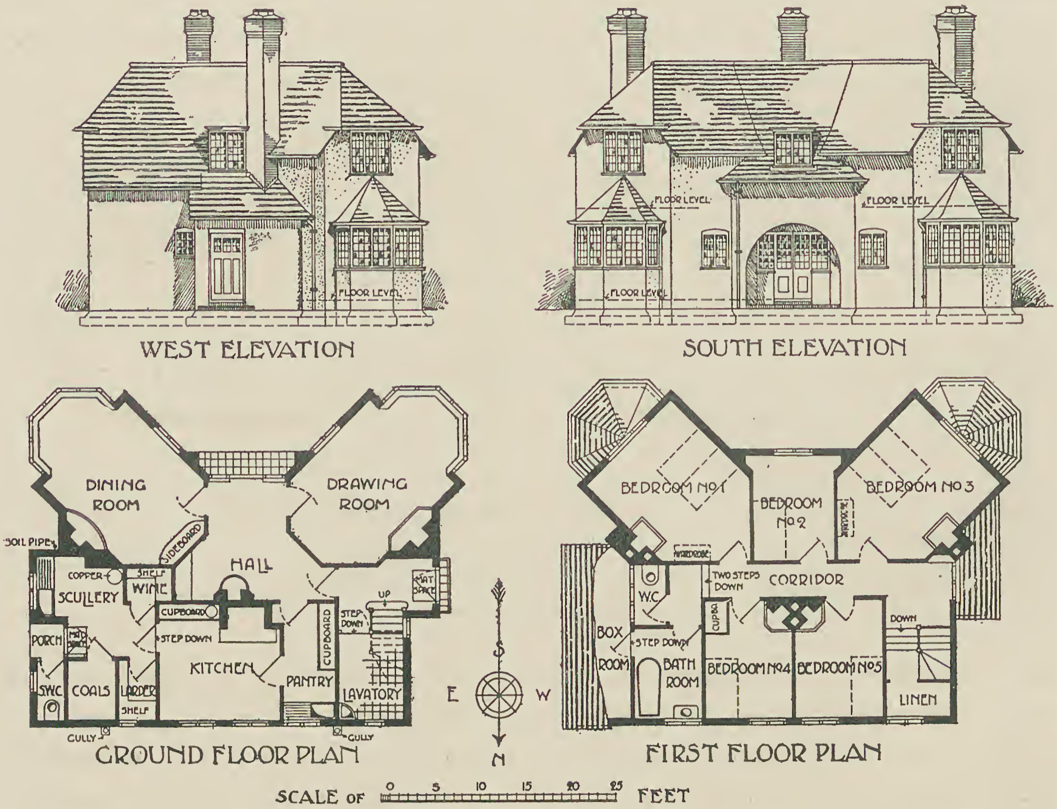


Fig. 28.—House with Hall and Two Sitting-rooms

in the west end, the servants' or tradesmen's entrance in the east end, and the garden and garden entrance on the south side. The dining-room is turned at an angle, so that the bay faces south-east and receives the morning sun, and the drawing-room is turned to the south-west. The hall faces due south. The kitchen has a north aspect, and is separated from the hall by a small pantry, but more direct service to the dining-room can be obtained if desired, by way of the store-room marked "Wine".

The house shown in figs. 29 and 30 has a larger hall, and the rooms are differently arranged to suit the different site. The road is on the south-west

side, and the hall and drawing-room are placed on this side of the house. The verandah is at the south-east end of the hall, and has an opening on the south-west side, so that it has a sunny aspect throughout the day, but is at the same time sufficiently screened from the road and from the entrance path. The dining-room has a bay at the south-east end, and a smaller window on the north-east side overlooking the garden in the rear. A lavatory basin is fitted under the stairs, and a garden entrance is provided near it. The space under the lower flight of stairs forms a convenient store for games' requisites, boots, &c., and that under the upper flight for hats and coats. The kitchen is approached through the pantry.

Opinions differ as to the advisability of providing what are known as *square halls* or *sitting halls* in houses of this class. There can be no doubt that they give an appearance of spaciousness even to a small house, and that they are often both useful and beautiful; but many men regard such a hall as a luxury, and prefer that a third sitting-room or "den", however small, should be formed, in which they can secure privacy for writing, reading, and smoking. Although the house shown in fig. 29 was designed for clients who at the time desired a large hall, the hall was purposely planned so that a portion of it could at any time be converted into a third room by simply constructing a partition from the right-hand side of

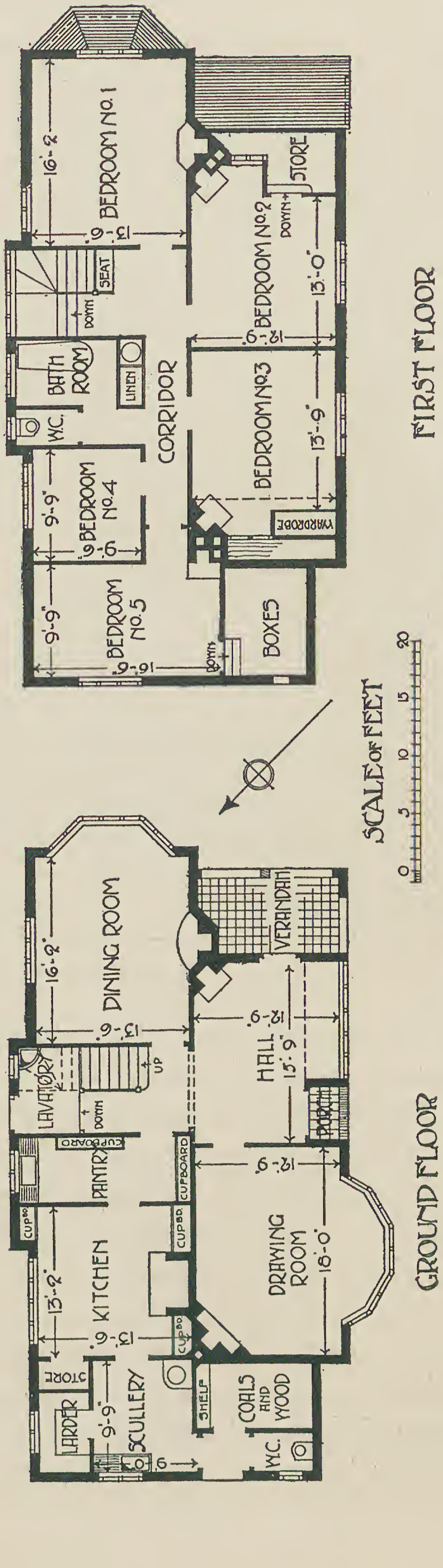


Fig. 29.—Plans of House with "Square" Hall and Two Sitting-rooms

the entrance to the left-hand corner of the dining-room. This provision for future alterations had its effect on the planning of the stairs, and rendered the service to the dining-room less direct than might otherwise have been the case; the wide opening between the hall and the staircase is, however, as high only as the doors, and is provided with curtains, which can be drawn before and after meals. As an alternative, a door or pair of doors may be fitted

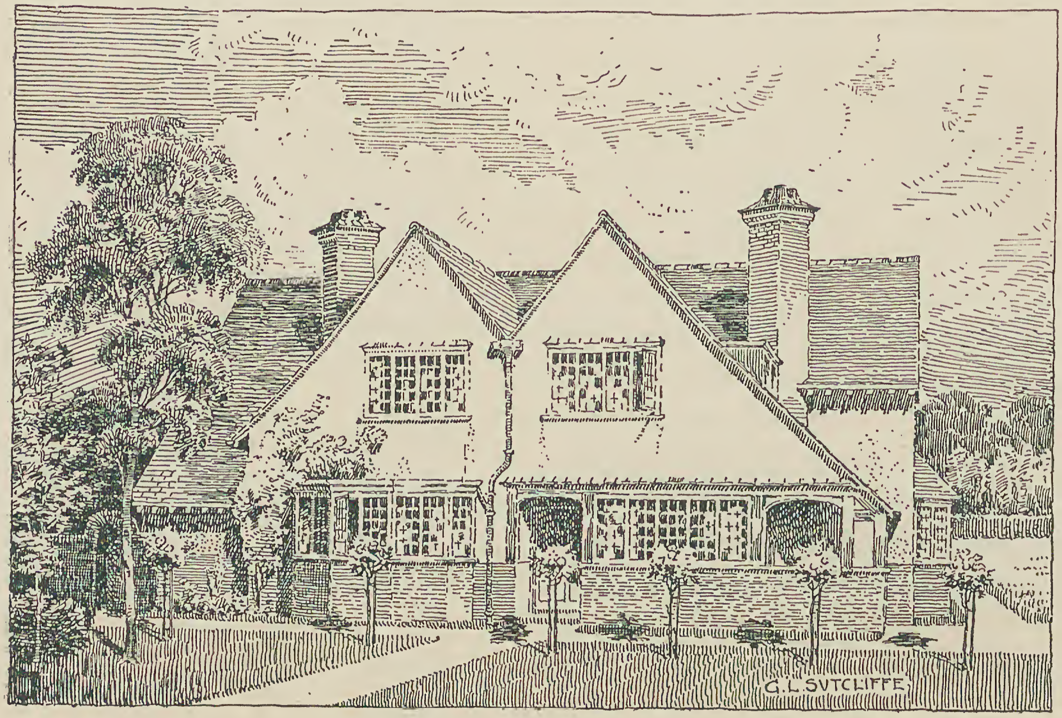
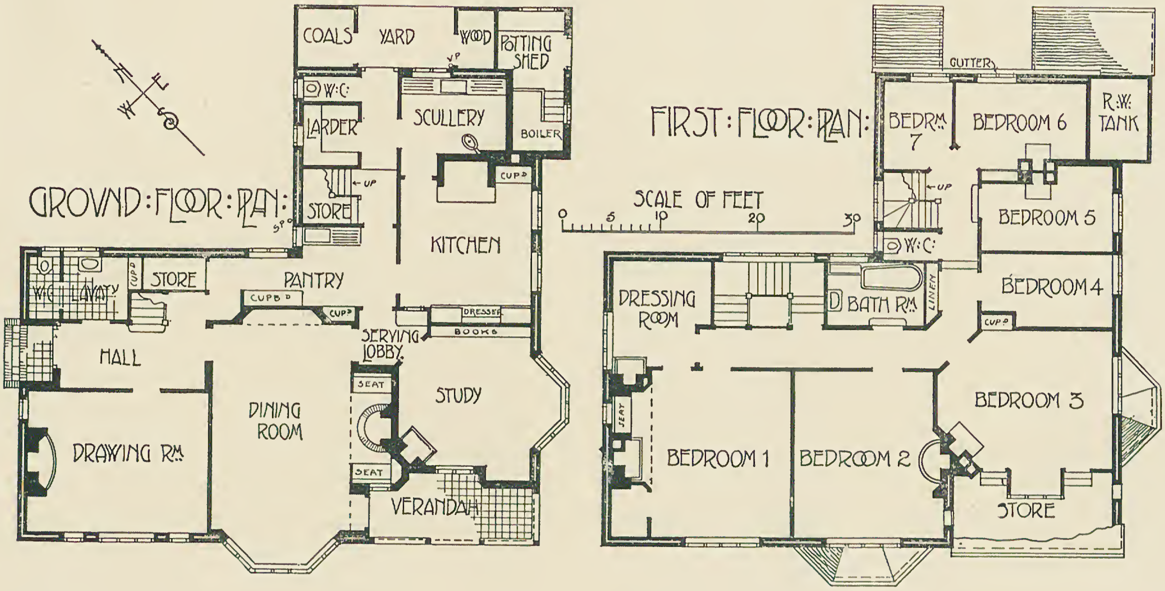


Fig. 30.—Entrance-front of House (for Plans see fig. 29)

in the opening. One advantage of placing the stairs away from the hall is that a second staircase for the servants may be dispensed with.

Houses with a greater number of rooms admit of a greater variety of treatment, and a large volume would be required to deal adequately with the subject. A few examples only of houses of moderate size can be given here. It is clear that in a larger house more servants will be employed, and this will influence the planning in a variety of ways. The kitchen must be increased in size, and a servants' hall may be required. A second staircase becomes a necessity, and two or more bedrooms for servants must be provided. The pantry may have to be a separate room fitted with a fireplace, and not a passage from the hall to the kitchen, and a strong-room may be required in connection with it. Two or more bathrooms may be required, and at the least three water-closets must

GARDEN FRONT (SOUTH-WEST).



HOUSE AT LEATHERHEAD, SURREY.

be provided, one on the ground floor, near the gentlemen's cloak-room, one on the first floor, and one for the servants. A housemaid's closet on the bedroom floor is necessary, and the other domestic offices must be increased in number and size. If menservants as well as maidservants are employed, the building becomes still more complex. The accommodation for the family and for guests must also differ in many respects from that in smaller houses. Not only will the rooms be larger, but they may also differ in kind. A billiard-room[1], for example, may be required, and another room may be set apart as a library, and a third as a schoolroom. A dressing-room will certainly be required in communication with the principal bedroom, and perhaps one or more communicating with one or more of the bedrooms for guests. In some cases a private bathroom must be provided in connection with the dressing-room. A large hall on the ground floor is more desirable than in a small house, and a second door for service to the dining-room is almost indispensable. Some kind of conservatory or winter-garden, entered from the house as well as from the garden, may be required, and other variations must be included. Among the more practical matters to be taken into consideration are the provision of a heating apparatus, with the necessary boiler-chamber and stores for coal and coke, and a more extensive system of hot-water supply, with probably an independent boiler. Plant for generating electricity, acetylene, or air-gas may also be required, but this must be placed in an out-building.

A house with a large hall or dining-room, two sitting-rooms, and six bedrooms is shown by a "model" in Plate XXVIII, and two views of the same house are given in Plate VA, and a view of the inner hall or dining-room in Plate XA. The hall is about 30 feet long, and has an ingle-nook at one end and an ordinary fireplace at the other, and a service-door is provided from the pantry. It will be seen that the plan differs from the ordinary type.

The house at Leatherhead, shown in Plate IC, is on somewhat similar lines in having the third sitting-room entered from the dining-room, but in this case the plan is arranged so that a passage can be formed along the back part of the dining-room if desired. This has not been done, as the space is of more value in the dining-room, and the use of this room as a passage to the third room has not proved in any way inconvenient. The house is on the slope of a hill, the two principal rooms and the verandah having a south-west aspect, and the third sitting-room a south-east aspect. A detailed description

[1] The ordinary English billiard-table measures 12 feet by 6 feet, and it is usually said that for such a table the room ought not to be less than 24 feet by 18 feet; rooms of rather smaller dimensions are sometimes provided, but are not wholly satisfactory.

of the plans is unnecessary, but it may be pointed out that small separate bedrooms were provided for children and servants, as this was considered to be better than placing two boys or two maids in one room. Although the building is low, a cistern-room and large box-room are provided in the roof. The roof-space over the verandah is utilized as a store-room in connection with the room marked " Bedroom 3 ", which is used as a nursery.

A larger house, with billiard-room, square hall, drawing-room, morning-room, dining-room, servants' hall, eleven bedrooms, &c., is shown in fig. 31.

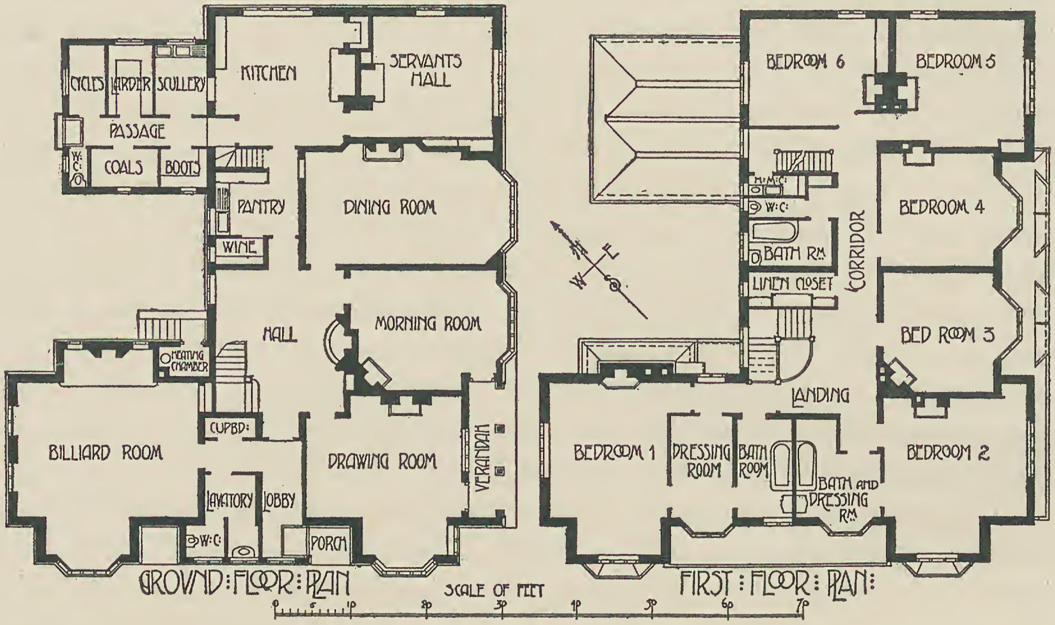


Fig. 31.—House with Three Sitting-rooms and Billiard-room

The billiard-room is placed near the gentlemen's cloak-room. A service-door from the pantry to the dining-room was originally shown, but was bricked up during the erection of the house. On the first floor there is a suite consisting of a bedroom, dressing-room, and bathroom, and another dressing-room with fitted bath is provided in connection with another bedroom. The central portion of the building has a lead flat level with the tile ridges, and space is thus obtained for five good bedrooms, a box-room, &c., on the second floor.

The preliminary designs for a house in Sussex are given in fig. 32. The principal entrance is on the northerly side of the house, and the accommodation includes a large hall, drawing- and dining-rooms, and library.

The materials to be used will depend in some measure upon the style of design required, and upon the local materials available, and the amount of

money to be spent. A brick building is almost invariably cheaper than one built of stone. As a rule an external wall of random stone, as in fig. 33, must be not less than 18 inches thick, but sufficient strength and equal protection against the weather can be obtained with a brick wall 9 inches thick covered outside with cement stucco, which may be finished either plain, or with a sand

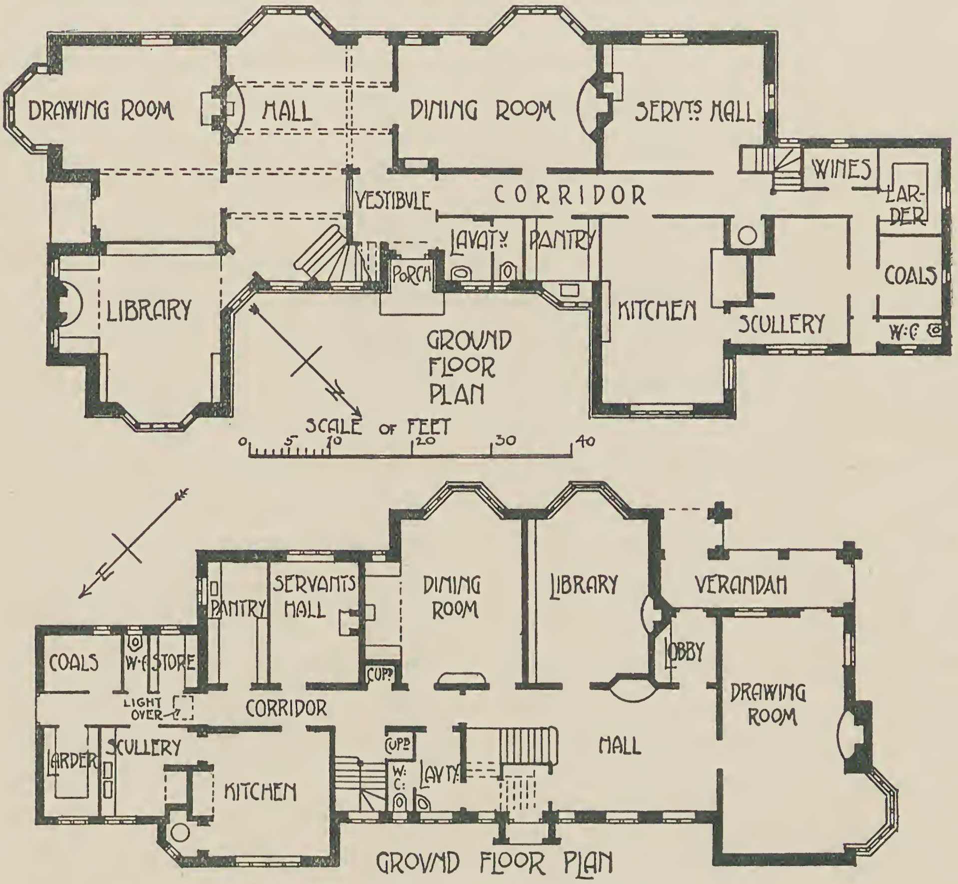


Fig. 32.—House with large Hall and Three Sitting-rooms

face or rough cast, as shown in figs. 28 and 30 and Plate Iᴅ. If facing-bricks are used, as in Plate Iᴄ, and No. 1, Plate XXIVᴀ, a bright uniform colour ought to be avoided, and this can usually be done by using all the sound and well-burnt bricks from a selected kiln, in which the bricks have been so stacked that the fire has access to the side and end faces of a sufficient number of bricks. In exposed situations brick walls must be built hollow, either with two half-brick walls enclosing a cavity, or (for good work) with a whole-brick wall on one side of the cavity and a half-brick wall on the other. The house

shown in fig. 30 has a hollow brick plinth of this kind and rough-cast brick walls above. Half-timber work, with cement panels, is usually more expensive than the walls described above, as building regulations almost invariably require the timbers to have a half-brick wall behind them and a half-brick filling between them, so that the walls are practically 9-inch brick walls with the timber added. Stone dressings for windows, doors, &c., may be effectively used with brick walls.

In many districts the by-laws require the walls to be of brick or other hard and incombustible materials not less than 9 inches thick, but in localities where there are no by-laws in force, cheaper walls can be constructed with timber framing covered with weather boarding or other suitable material. To retard decay, the timber framing ought to rest on a brick or stone plinth in which an efficient dampcourse has been laid, and if the timber is thoroughly saturated with creosote its durability will be greatly increased. Sometimes concrete blocks or slabs can be economically used, and for the internal walls or partitions somewhat similar slabs, 2 or 3 inches thick, are often cheaper than half-brick walls.

For permanent houses the roof-covering is usually slates or tiles. Ordinary blue Welsh slates are light and durable, but are far from satisfactory from the artistic point of view. The small slates of the thicker and rougher qualities are cheaper to buy and have a much more pleasing appearance. Slates of a rough texture and variegated colours can also be obtained from certain quarries in Wales, and other excellent slates from Devonshire and Westmorland. Stone slabs, known in some districts as "grey slates", form an efficient roof-covering, and are to be preferred before ordinary slates for country houses. Thatch (fig. 33) is still occasionally used for covering small houses and bungalows, where picturesqueness is more desired than durability. It affords a good protection against changes of temperature, but is inflammable in dry weather and harbours insects, &c. Reed thatch is more durable than straw thatch, but under the most favourable circumstances a thatched roof must be renewed every thirty or forty years, and in damp or exposed situations it may not last twenty years. Corrugated iron laid on boards is sometimes used for cheap week-end cottages and bungalows, but cannot be recommended. Tiles are perhaps the most popular roof-covering for country houses, but care is necessary in their selection and also in the method of laying. Some tiles are "pressed" and burnt to such a degree that moss and lichen cannot grow on them; these tiles are durable and practically impervious to moisture, and the "brindled" variety has some diversity of colour. Other tiles are made with

a sand face, which favours vegetation, and others again are stained to imitate old tiles. Hand-made tiles with a rough texture can also be obtained, and it is often possible to buy old hand-made tiles in excellent condition.

The architectural treatment of the house will be governed to a great extent by the temperament and education of the designer. One architect may have a decided preference for symmetry, another for quaint irregularity, a third for simplicity, and a fourth for ornateness; some may lean towards one or other of the recognized styles or varieties of architecture, and others may be

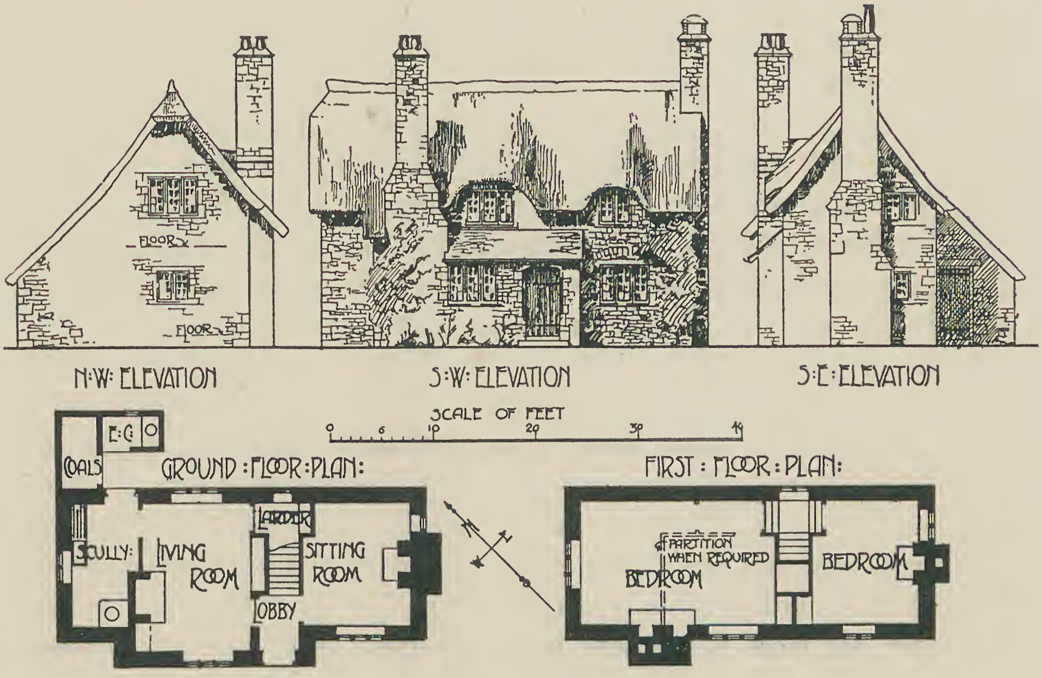


Fig. 33.—Stone-built Cottage with Thatched Roof

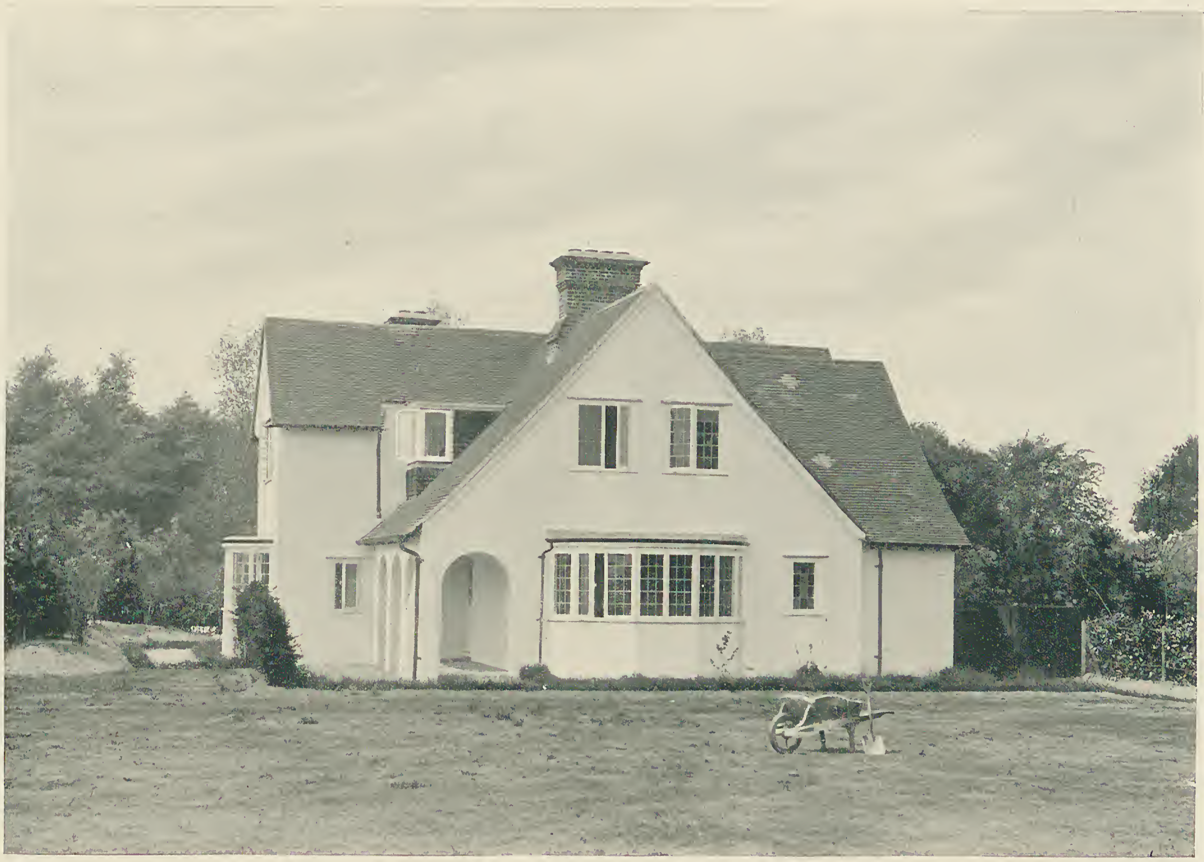
enamoured of the newest of new art; and all may produce designs which are good of their kind, although the designs will appeal to us with varying force according to our own prepossessions. It is therefore with considerable diffidence that the writer approaches this subject, knowing that after all he is merely expressing his own preferences and limitations.

The history of architecture is a record of different modes of expression in building, and the varied modes of expression are commonly known as **styles of architecture.** Strictly speaking, some of the so-called styles are merely varieties of one style which embraces the whole group; but as the term is convenient it may be retained. Of the English styles of architecture the most suitable for country houses are those ranging from the end of the fifteenth

to the eighteenth century—in other words from Tudor to Georgian. The present tendency is to adopt one of these indigenous styles in preference to an alien style such as that known as Italian, and this tendency is in the right direction. If it is allowed full play it will lead us also to adopt in a particular district the interesting modifications of style which were introduced in that district in consequence of the use of local materials. One of the practical details to be settled before designing a house is the kind of window to be used. Casements are suitable for styles in which the windows are divided by mullions into narrow lights, but sash-windows (see No. 4, Plate ID) require wider openings, such as those in "Georgian" buildings. It is true that sashes have often been used in modern mullioned windows, but the result is not satisfactory—partly because they give rise to a feeling of incongruity, and partly for practical reasons. Other considerations, such as the loftiness of the rooms and the number of stories, will also influence the choice of style. Whatever style is selected, a slavish imitation of old work ought to be avoided. What is required is the spirit of the style selected, and not a re-arrangement of its dead bones. This feeling for style will find an expression in the simplest cottage.

In the design of a house there are some points on which there ought not to be room for much difference of opinion, but unfortunately there is. One of these is that in a small house **a simple homely appearance** ought to be aimed at, but the rows of suburban villas with spiky turrets, elaborate balconies, and fretwork wooden arches show that other opinions are held. It has already been pointed out that one of the means of obtaining the homely appearance is to keep the building low in proportion to its length. This is not always an easy matter, but more can be done in this direction than is sometimes thought possible. A long roof-slope carried down to a low level over a verandah, as in Plate IC, or over a verandah and outbuildings, as in No. 1, Plate ID, is one way of obtaining the desired effect without any serious loss of height or space in the building. When rooms are required on the second floor, they can usually be obtained without carrying the roof up to a disproportionate height; in the example given in Plate XIXA the roof-slopes terminate at the level of the ceilings of these rooms, and a lead flat is constructed over the central part of the building. Another method of reducing the apparent height consists in the use of a curb, or Mansard roof, as shown in Nos. 1 and 2, Plate XXVII.

In a small house, fussiness and excessive ornamentation ought to be carefully avoided. Many of the most interesting and picturesque old houses are almost entirely devoid of ornament, and, on analysis, it is found that their



No. 1

No. 2

GARDEN FRONTS OF TWO SMALL HOUSES.

charm is due in a great measure to the pleasing proportion and balance, the comparatively large areas of plain wall, the careful (though in some cases apparently careless) disposition of the windows and doors, the mass or outline of the building, the position and design of the chimneys, and the harmonious colours of the materials employed. In large houses a more ornate treatment is permissible, but no amount of ornament will hide the essential ugliness of a building which is seriously defective in its general design, just as the best colouring will fail to convert a bad drawing into a good picture.

The question of colour is one to which little attention has been given, although it is of the greatest importance. It is sometimes thought that the charming colouring of old buildings is entirely due to Nature, but this is not the truth. If old brickwork is examined, it will be found that the bricks are not, and never were, of the same colour, but vary in tone from light- to dark-red and on to purple and to dark-blue. Bricks with a similar range of colour can be obtained to-day, and if they are properly laid they will have a delightful effect even when new, as different as possible from the monotony of "best red facing-bricks", or of the red wash with which the speculating builder covers his brickwork. A draught-board effect, due to the use of light stretchers and dark headers alternately, must be carefully avoided. If roofing tiles are used, they must be selected to harmonize in colour with the brickwork, otherwise the colour effect of the building may be utterly spoilt until age has toned down the roof and creepers have overgrown the walls. The ordinary "blue" Welsh slates are not beautiful at any time, but are more objectionable on a red-brick country house than on one of stone. Slates of rougher texture and more varied colour can be obtained. In the selection of building stone the same regard for colour must be had. The colour of stone commonly used for building, ranges from creamy white to dark bluish-grey and from light buff to dull red, and may be uniform or variegated in different ways. For country houses stone having a natural variety of colour is the best, and if the stone is to be used with brickwork the colours of the two materials must harmonize. One advantage which stonework has over brickwork is that by the use of stones of different sizes and shapes, as shown in fig. 33, a greater variety of texture and colour can be obtained.

Mass or form, by which is meant the general composition of the building as distinguished from its details, is also of great importance. Although the external treatment ought to express the internal arrangements of the building,—in other words, although the elevations ought to follow naturally from the plan—the plan must not be designed as a thing by itself, but always in its

relation to the external treatment. This must not be taken to mean that the plan must be spoilt for the sake of the elevation, but that a plan which does not admit of a satisfactory external treatment is lacking in some of the qualities of a good plan. The fact that a building has the appearance of solidity or mass, and is not a series of plane surfaces like those in architectural elevations, must never be forgotten by the designer. A roof-slope, for example, which may look well in elevation may appear too low in the actual building, especially if the roof is hipped. Another point to be borne in mind is that

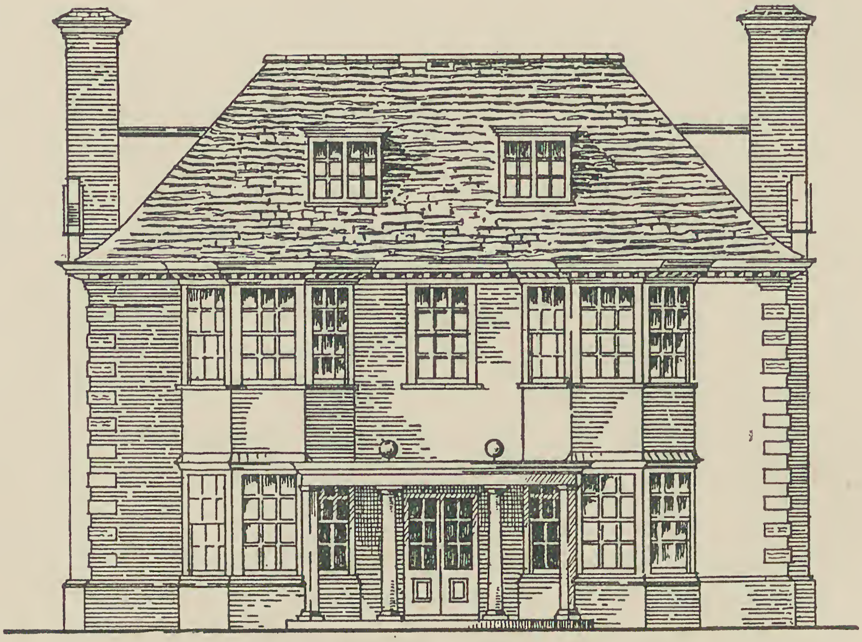


Fig. 34.—Garden Front of "Georgian" House.

a country house is seen from different points of view. It is therefore a mistake to give careful thought to one side only and to allow the others to take care of themselves. The designer must not allow himself to imagine a house as consisting of a front, a back, and two ends, but must at the least think of it as having an entrance-front and one or more garden-fronts. The four sides will differ in importance and in treatment, but each ought to be interesting and in harmony with the other sides. In the general composition of a building the chimneys are of great importance. This is true in the case of an irregular composition, where a certain balance is desirable, but the problem presents greater difficulties when symmetry is the leading feature of the design. In a house of "Georgian type", for example, such as that shown in fig. 34, symmetry ought to be observed in the position and design of the chimneys

as in the other features, and the plan must be considered from the beginning with this end in view.

The details of the building must be in harmony with the style adopted, not only on the principal front but on all the sides. There is scope for great variety and individuality in the position and design of the windows, doors, chimneys, gables, and other features, and skill and care are as necessary in the details as in the other parts of the design. Apparently trifling matters, such as the curve of roof-slopes near the eaves, have a great effect on the appearance of the building. Undue crowding of windows must be avoided, and it must not be forgotten that proportion must be observed between the size of each window-opening and the house itself. In many old houses the separate lights in mullioned windows are only about 1 foot in width and 3 feet or less in height, and, although these dimensions are for practical reasons too little, they cannot be increased indefinitely without destroying the scale of the building.

Internal Design.—The hall and principal rooms of a house ought to be designed so that they are not only comfortable and convenient but also pleasing to the eye. Comfort and convenience have been considered in the first part of this section, and a few words will be added here on the artistic aspect. In the first place, it may be said that variety is desirable in the shape of the different rooms and in their decoration. A rectangular room has an appearance of greater space than an irregular room of equal area, but it is much less interesting. Bay windows, ingle-nooks, and other recesses add much to the charm of a room. There is scope for almost endless variety in the design of the fireplace, and particular attention ought to be given to this feature, as in winter it is the centre of attraction. In summer the windows are more important, and they also require careful consideration.

In Plates IIIA and XA two views of the hall and staircase at "Woodlea", Woldingham, are given. The panelling, stairs, and ceiling beams are of oak. The panelling is finished with a moulded cornice forming a shelf for plates, and above this is a plain frieze. The fireplace recess is built of bricks, and is surrounded with carved and moulded oak posts and lintel. Above the dog-grate is a canopy of armour-bright iron. Another panelled hall is shown in No. 1, Plate XVA, and the landing of a smaller house in No. 2, Plate XXIVA.

The sitting room of a country cottage is shown in Plate IIIA. The principal feature of this room is the ingle-nook with its large brick arch, dog-grate and copper canopy, and seats. A picture-rail is carried around the other walls at the height of the doors, and the space between this and the skirting will

eventually be papered. No. 3, Plate XVA, is a view of the fireplace end of a morning-room, and No. 3, Plate XXIVA, shows the ingle-nook in the "den" in the same house. In this case the walls of the room itself are plastered, but the whole of the ingle is faced with red bricks. In the dining-room at "The Dover" (Plate XA) the ingle is faced with red bricks, but in this room there

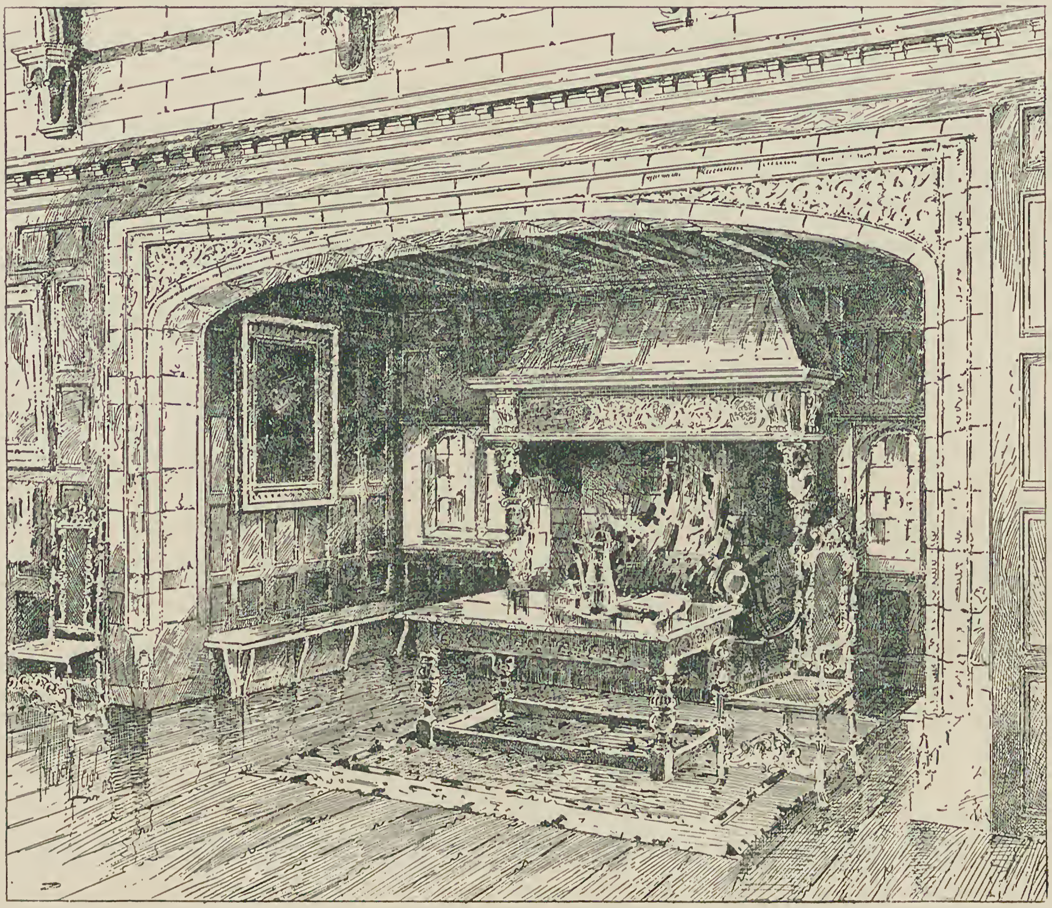
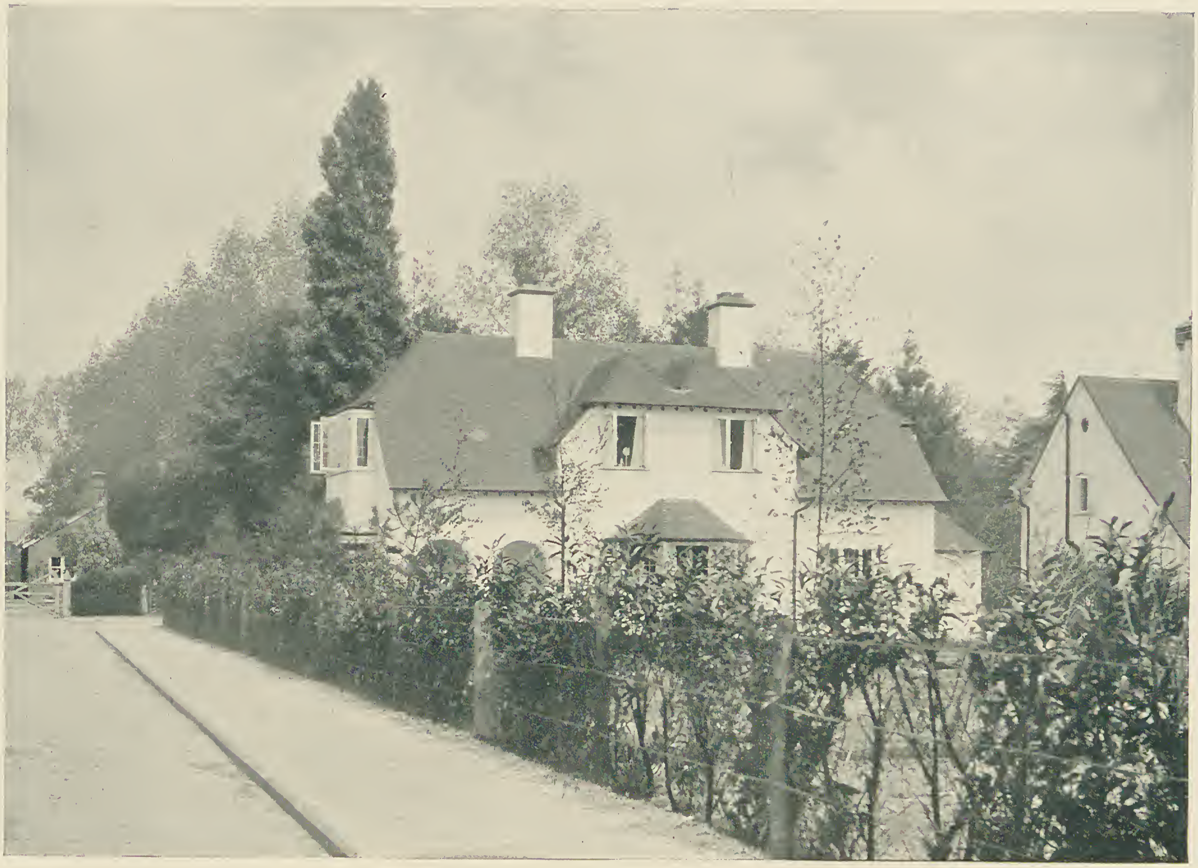


Fig. 35.—Ingle in Top-lighted Dining-room.

is also a frieze of red bricks. Below the frieze the walls are plastered, but it was intended to cover the plaster with brown paper. The beams and joists of the floors over are partly exposed in the ceiling. Fig. 35 shows part of a dining-room built from the writer's designs as an addition to a large country house. The room was designed to receive a number of valuable pictures by old masters, and for this reason the principal light is obtained from two ranges of dormers in the open roof. The panelling, roof-timbers, and other woodwork are of oak, and the arch, frieze, &c., of Ham Hill stone. Three examples of



No. 1

No. 2

TWO SMALL HOUSES.

simple bedrooms are given in Plate IB, and an example of a dressing-room in No. 2, Plate XVA.

In a house of "Georgian" type a good effect can be obtained at little cost by planting small wood mouldings on the face of the plastered walls to form panels. A dado-rail about 3 feet from the floor is often planted on in the same way. The whole of the plaster and wood mouldings can be painted, a stippled surface having the best effect. For ceilings and friezes plain white distemper is suitable where elaborate ornamentation is not desired. Plaster intended to be distempered is often finished with a sand face; the rough surface thus obtained is particularly suitable for country cottages. The best covering for the walls of halls and dining-rooms is panelling (preferably of oak, wax-polished), but wall-papers, canvas, linen, embossed cardboard, fibrous plaster, and other materials are now made in endless variety for covering walls and ceilings, and many of these can be used with good effect. The hearths and surrounds of fireplaces, and the floors and walls of bath-rooms, &c., may be finished with glazed or unglazed tiles of various colours, mosaic, marble, and other materials.

In the decoration of rooms the aspect and use of each room must be taken into consideration. A cold dull green, for example, is not the best colour for a sitting-room with a north aspect, nor is a bright red suitable for a bedroom. At one time it was the fashion to adopt a dark scheme of decoration for dining-rooms, but to-day there is a desire for brighter and more cheerful rooms, and even for dining-rooms an all-white treatment is not unknown. It is probable that there will soon be a reaction against the prevailing taste for white paint, and a return to coloured pigments, but it is not likely that the dingy colours which found favour about thirty years ago will be the next fashion. For bedrooms white or ivory-white paint is the best, and the wall-papers or other coverings should be light in tone and not too conspicuous in pattern. If the windows are large and well-distributed, a darker scheme of decoration may be adopted with advantage.

CHAPTER III.

TOWN AND SUBURBAN HOUSES.

In the first chapter a number of plans suitable for **artisans' houses** in towns were given, and nothing further need be said on this part of the subject.

The principal difference between **town and country sites** for larger houses is that in towns the sites are almost invariably smaller than those available for houses of a similar class in the country. Whether the land is sold by the square yard or by the "foot frontage", the price is usually such that the frontage must be very little in proportion to the class of house to be built. In an extreme case terrace-houses must be erected so that every foot of frontage is utilized. If a little more land is available semi-detached houses may be built, and for larger sites the houses may be detached, but even in these cases the space between the buildings is usually so narrow that the only windows which can be placed in the end walls are those of staircases and offices. The windows of the principal rooms must be in the front and rear walls, as in the case of a terrace-house, whatever the aspect and prospect may be.

Terrace-houses are still being built in the more expensive residential parts of towns and cities, but not to the same extent as in years gone by. In suburbs semi-detached houses have been preferred for some time, but the modern demand is principally for detached houses. The usual arrangement is a building of three or more floors, the lowest story or basement being partly below the level of the street. On this floor the kitchen and offices are placed, and perhaps also a family-room used as a breakfast-room. On the ground floor there are usually two rooms (one in the front and the other behind) and the entrance hall and staircase, and on each of the upper floors there are two or three bedrooms and dressing-rooms (see fig. 8), and on one of these floors a bath-room and water-closet. In the larger houses the drawing-room is usually on the first floor, the two rooms on the ground floor being then used as dining-room and library. A small wing is sometimes built out at the back, in order to provide additional accommodation, the floors being in many cases level with the half-space landings of the stairs. In London the by-laws allow the "space" in the rear of such houses to be built over to the height of 16 feet above the level of the street, and by taking advantage of this permission a large top-lighted room can be obtained on the ground floor. Many of the most highly-rented terrace-houses in London and other towns are far from satisfactory from a hygienic point of view. The basements and some of

the rooms on other floors are often badly lighted and ventilated, the open space in the rear being too small to allow sufficient fresh air and sunshine in the rooms. Another objection is that the prospect from the back windows is often nothing but dingy brickwork. For these and other reasons terrace-houses

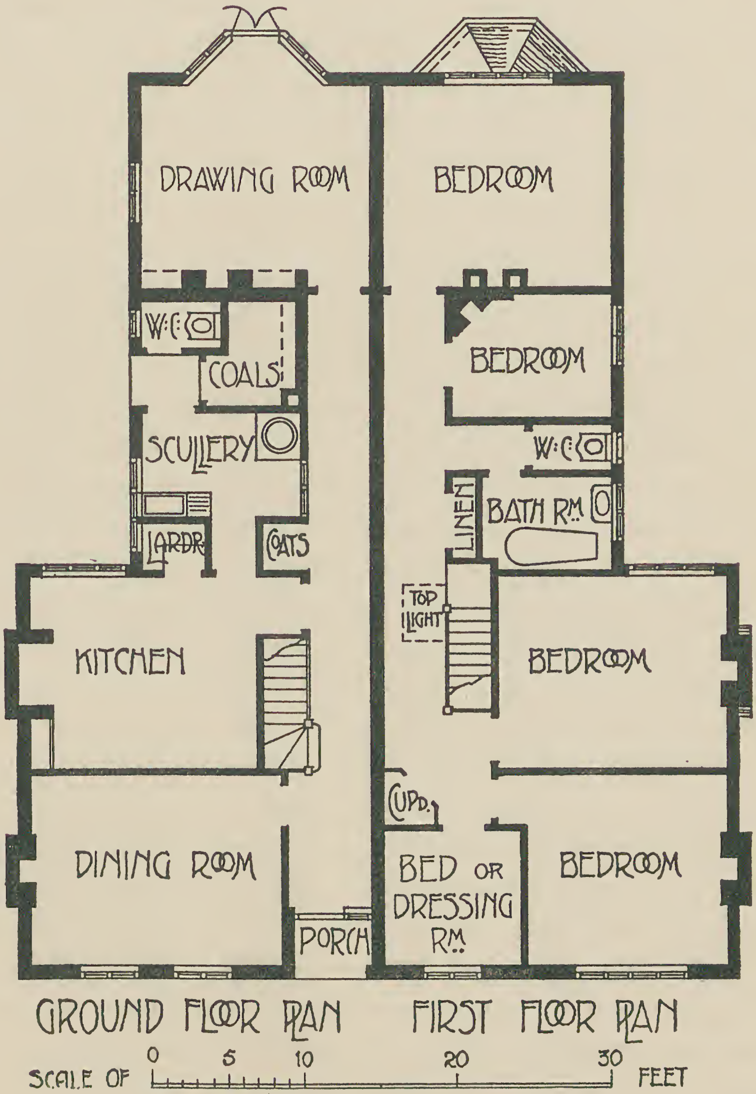


Fig. 36.—Semi-detached Houses with Narrow Frontage.

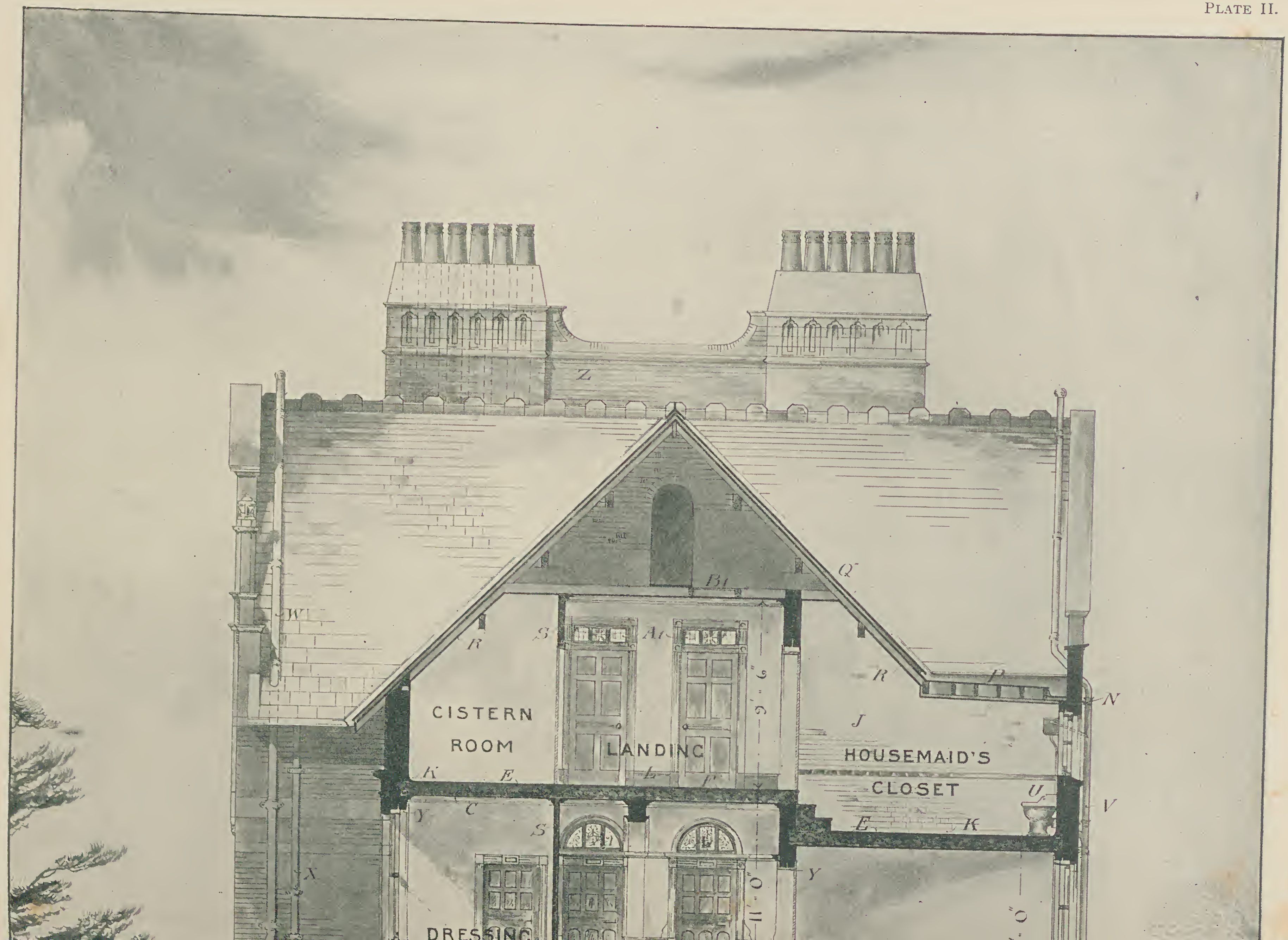
with basements are in less demand than formerly. Many are now let as apartment-houses, and others have been converted into tenements or flats.

Semi-detached houses are better than terrace-houses as there is a better circulation of air around them, and as a rule the open space in the rear is large enough to be used as a garden. Many of these houses have basement rooms

(Plates II., XIV., and XVIII.), but this arrangement is not often adopted to-day, as a basement story adds considerably to the domestic labour. For sites with little frontage a favourite plan is that shown in fig. 36. The kitchen and offices are placed on the ground floor in the middle of the building; the dining-room overlooks the road in front, and the drawing-room is placed in a wing overlooking the garden in the rear. This arrangement is a great improvement on the earlier type, in which the second sitting-room occupied the place of the kitchen, and the kitchen and offices were placed in the wing. On the first floor four or five rooms can be obtained besides a bath-room and w.c., and two or three additional bedrooms can be obtained on an upper floor over the front part of the building.

The pair of houses shown in Plate I. was designed for a site near London. The plots were rather small from front to back (about 130 feet), but the frontage was nearly 50 feet. In each house the entrance-hall and kitchen are on the north side, the two sitting-rooms on the south or garden front, and the scullery and offices at the end. The party-wall is $13\frac{1}{2}$ inches thick up to the level of the first floor, in order to deaden the sounds made by more or less musical neighbours, and is carried up above the roof to prevent the spread of fire.

Detached houses are now preferred in suburbs, and follow in the main the lines laid down for country houses, the principal difference being in the position of the kitchen and offices. These ought to be placed at the less sunny end of the house. The other end and the entrance and garden fronts can then be left for the principal rooms, and these elevations will not be spoilt by unsightly outbuildings and yards. In a house of this kind the garden front is usually the most important, and the greatest care must be taken to make it a thing of beauty. The speculating builder's house shown in No. 1, fig. 37, is one which remained unoccupied until the writer altered it as shown in No. 2. The site was about 250 feet deep and 50 feet wide, the frontage being towards a road at the westerly end. The house was built 3 feet 6 inches from the southerly boundary, and on this (the sunniest) side there were no windows. The principal entrance was in the middle of the front, and on each side of this was a room with windows facing west by north, one of these rooms having also small windows in the fireplace recess on the northerly side of the house. A wing, built out at the back of the house, contained the scullery and other offices, and not only interfered with the prospect from the third sitting-room, but also spoilt the appearance of what ought to have been the garden front. In the planning of this house no thought had been bestowed on either aspect or prospect, or on the design of any side except the entrance front.


CISTERN
ROOM
LANDING
HOUSEMAID'S
CLOSET
DRESSING
Z
W
R
S
A
B
Q
P
N
J
U
V
K
E
L
F
C
Y
X
9' 6"
11' 0"

SECTION THROUGH SUBURBAN HOUSE.

A. Concrete ground-layer, 6″ thick.
B. Asphalt damp-course extending over walls, ground-layer, and area.
C. Concrete floors.
D. Fawcett's fire-proof flooring, consisting of tubular earthenware lintels, steel joists, and concrete.
E. Terrazzo floor-surfaces.
F. Wood-block flooring.
G. Parquet flooring.
H. Tiled flooring.
I. Tiled dado.
J. Glazed brickwork.
K. Curve formed in terrazzo or cement.
L. Cement skirting.
M. Slate window-ledges.
N. Asphalt damp-course under parapet and gutter.
O. Glazed roof (the roof of balcony also to be glazed above all windows).
P. Lead flat.
Q. Roof formed with boards, felt or Willesden paper, raking and horizontal laths, and Westmoreland slates.
R. Laths and plaster.
S. Concrete-slab partitions.
T. Sinks.
U. Slop-sink with cistern over.
V. Waste-pipe from slop-sink and ventilating-pipe for back-drains.
W. Ventilating-pipe for front-drains.
X. Rain-water pipe.
Y. L-shaped steel lintels.
Z. Party-wall carried above roof.
A 1. Door fanlights made to open.
B 1. Manhole for access to loft.

If an additional plot of ground could have been obtained on the southerly side, the house could have been altered in a more satisfactory way, but as this was impossible a plot 25 feet wide was added on the north side, and the principal entrance was placed on this side. The kitchen was converted into a hall, and the morning-room into a kitchen, and the old wing was partly pulled down and a new drawing-room, verandah, and offices were built in its place, with

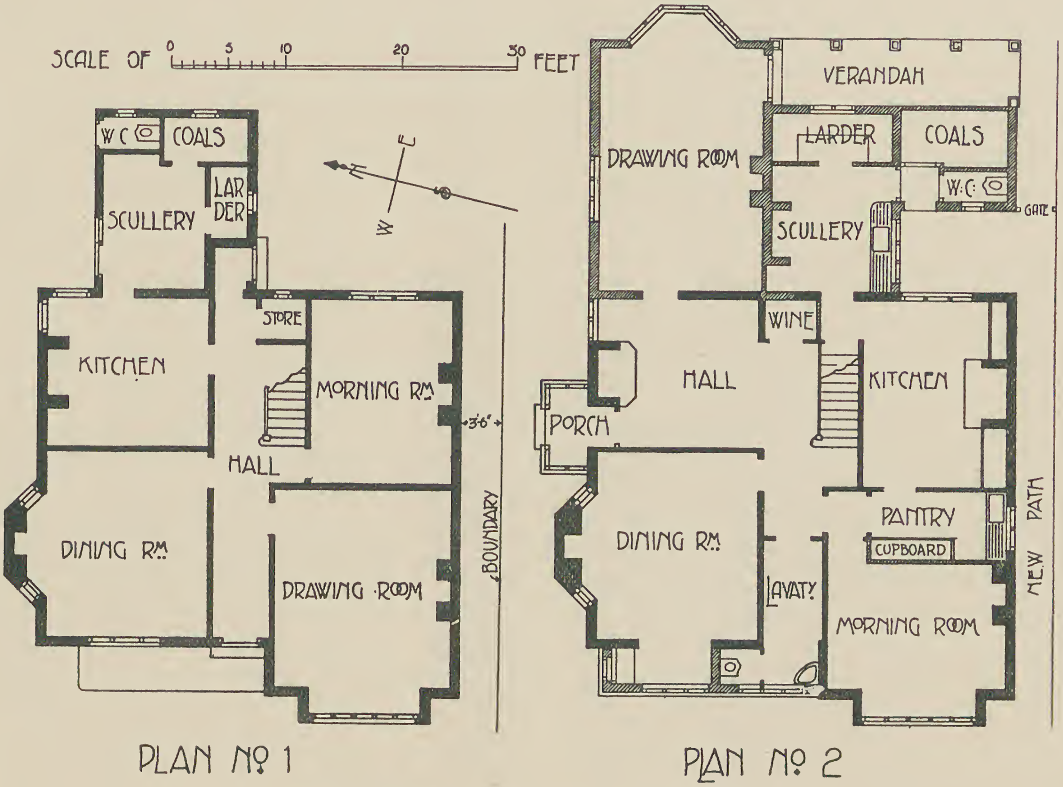


Fig. 37.—Detached Suburban House before and after Alteration.

a large bedroom, bath-room, w.c., and housemaid's closet over. Other alterations were also made as shown in No. 2, including the formation of a ground-floor cloak-room and w.c., and a pantry. It is clear that the house as altered is not satisfactory in every respect, but it is believed to have advantages over the original design both in plan and elevation, and there can be no doubt that the drawing-room and verandah form a better frontage to the garden than the former outbuildings.

As some of the plans given in Chapter II. are suitable for suburban houses, with perhaps a few modifications, reference to them may be of some use.

Tenements and Flats.—Detailed descriptions of tenement-houses and flats

would require a separate treatise, and would be beyond the scope of this work. That they supply a public want in large towns is obvious, but there can be no doubt that they lead to "overcrowding on space"—that is to say, to an excessive population on a given area—and in so far as this is the case they are from the sanitary point of view objectionable. In these days of cheap and rapid transit the necessity for erecting tenement buildings in the heart of large towns is much less pronounced than it was twenty years ago, and municipal authorities and others are beginning to learn that so-called "model dwellings or tenements" do not furnish the best solution of the housing problem. It is probable that there will always be some demand for tenements of this kind and for more expensive flats, but it is also probable that the supply in the future will be restricted by new building regulations devised to prevent overcrowding on space.

Section II.

CONSTRUCTION

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SECTION II.—CONSTRUCTION.

CHAPTER I.

THE PROBLEM STATED AND DISCUSSED.

The healthfulness of a house depends to some extent on the geological formation on which it is built, its position and aspect, the nature of the water-supply, the density of the population around it, the climate and other external circumstances; but it also depends largely on the materials of which the building is constructed, and the manner in which these materials are employed. A house may be situated in a salubrious locality and may have a plentiful supply of pure water, and yet not be fit for occupation.

And the fault need not lie in the drains or the water-closets. These and the sinks and other fittings may be as perfect as can be, and yet the house be dangerous to live in. This fact is apt to be overlooked. Drainage has been so much written and talked about of late years, that every house-hunter now-adays asks at once, "Are the drains all right?" He does not ask, "Are the walls, the floors, the roof all right?" and yet these have an important influence on the healthfulness of a house. The ill effects of defective walls and floors and roofs may not be so quickly manifest as those of bad drains and nasty fittings, but they are no less certain and dangerous; rheumatism and diseases of the respiratory organs are frequently caused by cold, damp, dusty, draughty, or smoky and ill-ventilated houses, and even if these ailments are not produced, vitality is lowered and the occupants of the houses become an easy prey to other diseases. In fine, the general construction of a building, quite apart from all question of the site, water-supply, sanitary fittings, drainage, and ventilation, may be responsible for its unhealthiness.

A damp house, it has been well said, is a deadly house. But dampness is not the sole danger. **The model house** will not only be dry; it will also be of equable temperature, free (as far as possible) from dust and smoke and air-pollution of every kind, filled with light and sunshine, and adapted for cleanli-

ness. It will be planned in such a way that no part of it will be close and stuffy, but every nook and corner receive an adequate supply of fresh air. Moreover, the model house will be reasonably safe from destruction by lightning and by fire.

1. *DRYNESS.*

Damp may enter a house from above, below, and from all sides. It may come through the foundations, floors, walls, roof, windows. It may be the result of ground-moisture or of moisture in the air, or may be caused by the back-flow of drains or by defective water-pipes and fittings. It is the cause of decay in wood, of rotting carpets, soiled wall-papers, swollen doors and drawers, dank smells, mildewed pictures and books, and even of smoky chimneys. Truly there are disadvantages in a damp house other than its unhealthiness.

To secure a dry house is sometimes difficult, but it is not usually impossible, provided funds do not run short. A few general rules may be laid down. They may be divided into two groups: the *first* consisting of those for the exclusion of ground-moisture, and the *second* for the exclusion of atmospheric moisture.

I. To Exclude Ground-moisture.

1. Drain the **subsoil.**

2. Lay over the whole excavated site under the lowest floor of the house an impervious **ground-layer** above the drainage-level of the ground.[1, 2]

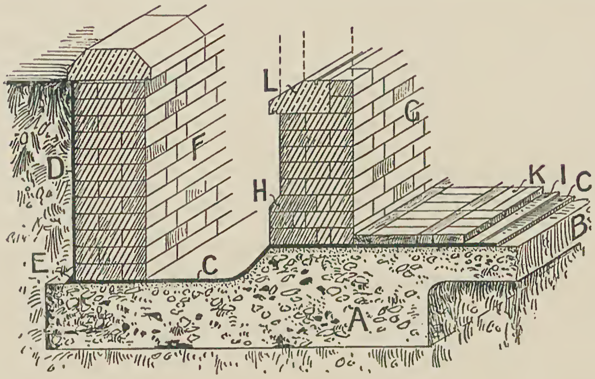


Fig. 38.—Concrete Ground-layer, Open Area, &c.

A, foundation of concrete alone; B, concrete ground-layer; C, horizontal asphalt damp-course; D, vertical asphalt damp-course; E, asphalt fillet; F, area-wall; G, house-wall; H, blue-brick plinth; I, mastic for wood-blocks; K, wood-block flooring; L, stone window-sill throated beneath, and grooved on top to receive weather-tongue.

3. **Cellars**, if well lighted and ventilated, render the rooms above drier.

4. Let the **ground-floor** (*i.e.* the principal floor) be well above the external ground.[1]

5. Let every wall have a horizontal **damp-proof course** above the external ground and below the ground-floor. If the basement is for habitation, let there be another horizontal damp-proof course just under the floor-level, and connect the two with a vertical damp-proof course outside the wall; or form an **open area** to a depth of about

[1] See Plate II. [2] See Fig. 38.

six inches below the basement floor.[1,2] So-called "dry areas" are useful, but not always satisfactory.

6. Build the **walls** with materials as impervious to moisture as possible, taking particular care about the mortar and the flushing and grouting of the joints.

7. Pave and drain the **yards and paths** around the house, so that the rain-water may be removed quickly and effectually.[1]

II. To Exclude Atmospheric Moisture.

1. Build the **walls** with materials as impervious as possible, taking particular care about the mortar and the flushing of the joints; in special cases, hollow walls may be used, or a small vertical cavity may be formed and filled with impervious material.

2. Lay an asphalt **damp-proof course** under all parapets and gutters.[1]

3. Let all **window-sills** project and be throated under,[2] and all **cornices** and projections be weathered on the top, so that the moisture will not be conducted into the wall but thrown clear of it.

4. Let the **eaves and gables** of the roofs project a foot or more beyond the walls:[1] this is one of the best preventatives of damp bedroom walls; but if ordinary parapets or eaves-troughs, and stone-coped or brick-coped gables are desired, let not the plumber be stinted in his lead.

5. All **slates and tiles** should be of good quality and should have sufficient lap; where the money can be spared, they should be laid on boards covered with waterproof felt.

6. If **lead gutters** must be used, they must not be laid level and the drips omitted or reduced to an inch or so; let the fall be as much as possible and the drips at least two inches, and do not forget snow-boards.

7. **A straight roof** can more easily be made water-tight than a roof with valleys, openings, and projections. All valleys, sky-lights, dormers, chimneys, are possible sources of leakage.

8. Birds' nests are often beautiful, but a sparrow's feather-lined hayrick is out of place in the head of a **rain-water pipe**. It is wise to take away the temptation by preventing access to the pipe.

9. **Windows and doors** and other exposed woodwork should be strong, of good material and workmanship. Sash-windows are more easily made waterproof than casements, especially if the latter open inward; leaded lights, in exposed situations, almost invariably admit rain, unless wide leads are used.

[1] See Plate II. [2] See Fig. 38.

10. Proper **warming and ventilation** are helps to dryness, because they prevent the condensation of moisture on walls. When the walls are built or faced with non-absorbent materials—whether cement, glazed ware, paint, or varnish—adequate warming and ventilation are indispensable for comfort. Ordinary walls, it is well known, "breathe", *i.e.* air passes to and fro through them, and a certain amount of moisture is in this way slowly removed from occupied rooms. That this is the case, may be easily seen in any house where some of the walls are painted and varnished, and some covered with ordinary unglazed paper pasted to common porous plaster; when the walls have been cooled by frost, or in cold weather by lack of fires for some days, a warm day covers the impervious wall with moisture, sufficient, perhaps, to trickle down in drops, while the absorbent wall shows little or no sign of dampness. The moisture contained in the warm air is condensed on the cold walls, and if it cannot find entrance, must remain till warming and ventilation remove it.

Damp, however, may be caused not only by moisture in the ground and air, but also by **defective water-pipes and fittings.** All water-pipes should be amply strong enough to resist the pressure to which they will be subjected, and must be carefully protected from frost. Safes and gutters should be provided where necessary, to take away the water in case of accident. It is surprising how long a small leak in a service-pipe or waste-pipe may pass undetected or unremedied.

2. *EQUABLE TEMPERATURE.*

A damp house is colder than a dry house, but a dry house is not necessarily of **equable temperature.** An iron building may be proof against the ingress of external moisture, but it will be cold in winter and hot in summer, for iron is a good conductor of heat. To prevent such extremes of temperature, iron churches are lined with wood, a material which conducts heat very slowly. A common illustration of the difference of the two materials in this respect is that of an iron poker and a wood brand, each with one end in a fire; the knob of the poker will sear the hand before the outer extremity of the wood becomes uncomfortably warm.

The **relative thermal conductivity** of different building-materials is, according to Péclet, approximately as follows:—Fir boards 1, plaster 2·8, brickwork 3·5, glass 4·8, stone 10, marble 18; and that of various metals used in building has been ascertained by Wiedemann and Franz to be as follows, silver being taken as the standard with a conductivity of 100:—Copper 73·6, brass 23·6, tin 14·5, iron 11·9, steel 11·6, lead 8·5. Water and air conduct heat only to a

very small extent, air being one of the worst conductors known; hence Nature's devices of feathers, fur, and wool, and the human inventions of hollow walls, double windows, ceiled attics, silicate cotton, and cocoa-nut fibre packing.

The use of a bad conductor of heat in conjunction with a material which is a good conductor of heat but practically impervious to moisture, is exemplified not only in the lining of iron buildings with wood, but also in the boarding of roofs under slates or tiles. The **slates** and **tiles** are practically impervious to moisture, while the boards retard the ingress and egress of heat. In the case of roofs, however, it is necessary to protect the wood from the moisture which may be driven by the wind through the joints of the slates or tiles, and this is done by covering the boards with a layer of **bituminous felt** or **waterproof paper.** This lessens both the perviousness and conductivity of the roof.

Brick is a worse conductor than stone. **Stone** walls should therefore be thicker than brick if they are to prove the same protection from extremes of temperature. Doubtless it is for this reason that the Education Department insists on stone walls being 20 inches thick, while solid brick walls need not exceed 13½ inches.

Plaster is a worse conductor of heat than either brick or stone. Not only, therefore, does it render a wall more sightly and amenable to decoration: it also adds to the comfort of the room.

Glass, on the other hand, is a better conductor than plaster and brickwork, and has the further disadvantage of being used in exceedingly thin sheets; it is the cause of more variation in temperature than any other portion of the structure of a house. The thickness of plate-glass is a point in its favour, and double panes are sometimes used, one on each side of the window-sash, in order to lessen the loss of heat through the window.

The superiority of **lead** over copper for roof-coverings, in respect of conductivity, is remarkably striking, but in practice the difference would not be much felt, as both are laid on boards which are themselves satisfactorily bad conductors.

The colour of materials has some effect on their absorption and radiation of heat. White and black are the two extremes, and between them, in order of absorption, are pale-yellow, dark-yellow, light-green, Turkey-red, dark-green, and light-blue. The glittering whiteness of the buildings on the shores of the Mediterranean and in other hot countries helps to keep them cool in the flaming sunshine, while in manufacturing districts in England the dark-slated roofs of many of the mills and weaving sheds are covered in early summer with whitewash to reduce the heat of the rooms beneath,—practical applications of this law of colour.

In any house the least **variation of temperature** is found in the basement rooms or cellars, the greatest in the attics. The variation is especially noticeable in attics where the slates or tiles are laid on laths without felt or boards, and where the ceiling is not plastered. Because cellars are of equable temperature, it must not be concluded that they are the most healthy of habitations. On the contrary, they are usually very much the reverse: they are generally damp, the temperature although equable is low, and they are insufficiently lighted and ventilated. The healthfulness of a house does not inhere in temperature alone, but in many other qualities of varying importance.

Warming and **ventilation** are, of course, the most important means of regulating the temperature of a house, and in the ideal arrangement the inlet and outlet of air would be under perfect control, so that the temperature of the house could be nicely maintained in spite of external fluctuations. But the cost and difficulty of warming and ventilating a building will be minimized if its construction has been considered with reference to the laws of heat.

The motion of the air is an important factor in the effect which temperature has on the body. A still, cold atmosphere is not as trying to the constitution as air in motion, even though the latter be somewhat warmer. Cold damp winds are more chilling than keen frosty calm. And in a house the motion of the air must be considered in connection with its temperature. Draughts are deadly, or at the least provocative of more or less dangerous and uncomfortable colds. The prevention of draughts is a difficult problem. There is no royal road to it. Much depends on the general arrangement of the rooms and passages, and on the relative position of fireplaces, doors, and windows; much also on the actual construction of the building so that the external walls, roofs, and windows do not absorb and radiate too much heat from the rooms. But the most important factors in the prevention of draughts are proper warming and ventilation. The draughty room is that where the fire must draw its supply of air from door and windows and gaping floor-boards; two or three inlet-ventilators in suitable positions would lessen the draughts, and at the same time make the fire burn better. Indeed, the air may be brought direct to a chamber behind the fire, and warmed there before being allowed to enter the room. Who does not know a room where the fire will not burn properly unless the door is left ajar? Unwarmed halls and staircases are prolific sources of draughts; it is false economy to leave these spaces without any arrangement for heating them.

3. *CLEANLINESS.*

Cleanliness, we are told, is akin to godliness, and dirt may be called a child of the evil one. The dust and smoke of our towns are responsible for more deaths than war. It is well known that dusty occupations are dangerous, the danger increasing with the hardness and sharpness of the dust. All dust is more or less injurious to the respiratory organs. Many "colds" are caused by breathing dust-laden air, and hay-fever is probably due to the inhalation of pollen grains.

But **household dirt** is complex. It includes *inorganic* matter of various kinds, such as fine particles of sand, clay, metals, and (more important than these) defiling soot; and also *organic* matter, the products of putrefaction and decay or emissions from living plants and animals, and comprising myriads of organisms, some of which may produce specific diseases in the persons breathing them or swallowing them with their food.

Of all the forms of household dirt, none is probably more detested by the good housewife than soot. The dry dust blown from a country road is what a child calls "clean dirt"; it is easily swept or brushed away. But the smoky air of towns defiles wherever it floats. No wonder that mistress and maids fast-bind windows and doors to exclude it, preferring close and stuffy rooms rather than admit the outer air with its concomitant filth. The purification of the air is a necessary feature in all schemes of house-ventilation in towns.

But since dirt is so prevalent, it behoves the architect to avoid as far as possible **all ledges, nooks, and crevices, and all unseen spaces** which could give it lodgment. Considered in the light of cleanliness, the ordinary floor, with its plastered ceiling below and gaping boards above, is radically wrong; so also is the confined space so often provided between the ground-layer and ground-floor; so also are lath-and-plaster partitions, hollow walls, and indeed all details of building-construction which provide spaces invisible and inaccessible to the householder. Sooner or later dirt finds its way to these dark places, and vermin breed and wander there, safe from the housemaid's broom and the cat's eager paw.

Floor-boards and blocks, skirtings, and other wood should be thoroughly seasoned, otherwise they will shrink and the joints be filled with dirt. Indeed, for many purposes wood is now frequently superseded by plaster of Paris or cement, and with manifest advantage, as in the case of skirtings and architraves. Plaster cornices with deep hollows and ledges and "bold" enrichments are an abomination. As far as cleanliness is concerned, gas-fires and gas-stoves are better than coal-fires, and the electric light is the best of all illuminants.

Compromise must, of course, enter into the construction of a house as into its plan and design. Cleanliness must be considered in relation to temperature and dryness and the other qualities desirable in dwelling-houses, but it is abundantly clear that sufficient thought has not hitherto been bestowed by house-builders on this important point.

The ideal house in respect of cleanliness is that into which air cannot enter till it has been freed from all impurities; which is built of such materials and furnished in such a manner that the production and retention of dust and dirt within it are reduced to the smallest limits; which burns its own smoke, and carries off all products of combustion, trituration, and decay as rapidly as they are produced; which is constructed so that there are no dark corners, no ledges, angles, and crevices in which dirt can linger; and, finally, which has an abundant supply of pure water, and lends itself to easy and rapid cleansing. Especially in bath-rooms, water-closets, sculleries, kitchens, and other rooms in which much water is used and more or less dirty work performed, the materials should be smooth and impervious; wood and common plaster should give place to concrete, glazed bricks or tiles, and cement. Even the joints of glazed brickwork are now often covered with impervious enamel paint.

In the construction of **hospitals** particular care is exercised in order that dust and germs may have no lodgment; the angles of floors,[1] walls, and ceilings are rounded; the moulds of windows, doors, and skirtings are designed without deep hollows; the materials used in construction are as hard and impervious as possible; and there is light everywhere. The principles which govern hospital construction should be applied to the construction of houses, for sooner or later every house is a hospital on a small scale, and the life or death of the stricken occupant may depend on its sanitary condition.

4. *LIGHT.*

"'**Let there be light**' is said to have been the first command, and truly no command should ever stand before it or bar its way. Pure light purifies, destroys the organic poisons of spreading diseases, makes a cheerful countenance, gladdens the heart, causes the blood to flow quickly, brightly, and of natural hue. Plants, the universal purifiers for man, which take up his breath, which live on his breath, and which give it him back again in food-produce, sicken and die if they have no light, but live and grow, and grow rich in the waves of this their natural inheritance. 'More light! more light!'

[1] See Plate II., and Fig. 42, p. 91.

exclaimed the dying German poet Goethe. 'More light! more light!' exclaims the sanitarian, as he looks on the masses that are dying prematurely in large dense populations, and, touched by Him 'who is clothed with light as a garment', sighs with them over their sorrows, sufferings, and oppressions."

The eloquence of these words of the late Sir Benjamin W. Richardson should not blind us to their truth. His description of the beneficial effects of pure light should be read as the message of science, and all engaged in building should ponder it carefully. The days of window-taxes are gone for ever, but some architects and builders seem to dread their reimposition if one may judge by the sparseness of the windows in their buildings. Only those who have been compelled to pass a considerable part of their days in twilight rooms can appreciate the blessings of ample light and sunshine, or forcibly enough anathematize those who, carelessly or to suit a passing craze, design windows rather for external show than for internal brightness and comfort.

To pass from the glare of summer sunshine into the cool dimness of a long low room lit by two or three low narrow windows, is a pleasant change, but the same room, in the days of cloud and rain, when books and embroidery are in our hands to while away the time, is a cheerless place till the lamps are lit. Doubtless a range of low-mullioned windows is pretty, and in the country, where the daylight is not obstructed, rooms may be pleasantly illuminated thereby, but the area of glass must be greater than would be necessary if the windows extended up to the ceiling.

Carelessness and fashion, however, are not always responsible for insufficient illumination. The architect may honestly attempt to light a room properly and yet fail; perhaps trees intercept the light, or lofty buildings.

Several **formulas** for proportioning the area of windows to the size of rooms have been devised, but the difficulty of the problem is manifested by the dissimilarity of the rules.

Here are a few of them;—[1]

1. Area of window $= \sqrt{B \times L \times H}$. (Morris.)
2. " " $= \frac{B+L}{8} \times \frac{B+L}{4}$. (Chambers.)
3. " " $= \frac{B \times L \times H}{100}$. (Gwilt.)
4. " light-aperture $= \frac{B \times L}{10}$. (London Building Act, 1894.)

[1] These rules have been reduced to the same terms for purposes of comparison:—B = breadth of room, L = length of room, and H = height of room. For a room measuring 15 ft. × 20 ft. × 12 ft. the rules give the following various estimates of window-space:—1. 60 sq. ft.; 2. 38 sq. ft.; 3. 36 sq. ft.; 4. 30 sq. ft. The architect must consider each case on its merits, as much depends on the shape of the room, the position of the windows, and the quality of the light falling on them.

Some of the difference shown by these rules is due to a difference in measuring the windows; the three first are intended to give the area of the opening in the wall, while the last is the exposed surface of the glass, in other words, the net light-aperture. This golden rule may, however, always be observed, "Try to err on the side of light"; the glare of excessive light may be subdued by curtains and blinds, by tinted glass, by plants and screens, by low-toned decoration, but darkness can only be expelled by the main force of mason and bricklayer.

The desire for light, however, must not lead us to forget that there is such a sensation as **cold.** The more window-space there is in a room—other things being equal—the colder will it be in winter, and also the hotter in summer. Increase of window-space must be compensated in various ways if the comfort and healthiness of the room are to be maintained; double windows may be provided, or (better) double panes of glass separated by a small air-space; or (best of all) radiators, connected with some system of heating-apparatus, may be placed in the window-recesses.

Shortsightedness is often increased, if not altogether caused, by the insufficient or improper lighting of **schoolrooms** and **workrooms.** The importance of window-design is recognized by the Education Department. The windows of class-rooms should be to the left of the scholars, and no room will be allowed in which one at least of the windows does not extend to the ceiling. In the design of **hospitals**, again, the extension of the windows quite up to the ceiling is a cardinal point, the usual arrangement being a sash-window in the lower part and a hopper light above. Every house is at times school and workroom and hospital, and this fact should be borne in mind when the windows of the house are being designed.

5. *AIRINESS.*

By **airiness** is here meant that condition of the house and its surroundings which ensures an adequate supply of fresh air to every corner both within and without the house. In other words, airiness is the converse of closeness and stuffiness. The rate of circulation within the house should be so gentle as to be imperceptible; outside it is best, except in the bleakest of situations, that the winds should have free play.

In the country **external airiness** can usually be attained, but architects sometimes go out of their way to prevent it by building deep and narrow recesses, or by arranging the house around a central quadrangle or court.

In towns the problem is more difficult, and stringent regulations[1] are necessary in order to prevent the repetition of those stifling courts and alleys which are the disgrace of most of our large towns.

Loftiness of rooms is an important factor in promoting **internal airiness.** In this respect continental buildings compare favourably with ours. In this country the minimum height of living-rooms and bedrooms as prescribed by building-regulations is usually 8 feet 6 inches or 9 feet, a height which in small rooms gives an utterly inadequate air-space for the occupants and renders ventilation extremely difficult.

In promoting the airiness of the house, ventilation of course plays an important part, and this will be discussed in a subsequent section, but much can be done by a proper disposition of rooms and passages, and a thoughtful arrangement of windows and door-fanlights made to open, especially those in halls, landings, and passages; the windows should extend as near to the ceiling as possible. Just as there should not be any corner where light does not shine, so there ought not to be any place where fresh air cannot circulate.

6. *FIRE-RESISTANCE.*

In towns certain precautions against **conflagrations** are now invariably taken, but in the country, where the chances of extinguishing a fire are much less than in towns, little or nothing is attempted. The upper walls of the country house may be constructed largely of wood, while the same material is used for roofs, floors, windows, doors, skirtings and dadoes, mantel-pieces, partitions, and stairs. From basement to ridge fuel is provided for the flames. Never a winter passes but we read of the destruction by fire of part at least of some historic mansion with treasures of art which cannot be replaced. For small houses the cost of fire-resisting construction is unfortunately prohibitive, but for large houses and for flats and hotels the extra cost is money well spent.

The subject of **fire-resisting construction** is both important and extensive, and only the fringe of it can here be touched. It is a question of materials, and also of their arrangement; for instance, an ordinary floor of wood joists and boards is a most dangerous piece of construction, while a *solid* wood floor of the same thickness possesses fire-resisting properties of great value.

Materials may be classed as *combustible* and *incombustible.* Wood is by

[1] In London the principal regulation is that each building of the domestic class must have an open space in the rear not less than 10 feet deep, and of the full width of the building, and the upper stories must be set back so that the horizontal distance of the wall at any point in its height from a vertical line drawn from the rear of the open space must be not less than half the height of the wall at that point above the prescribed ground-level.

far the most important combustible material used in a building, and the less that is used the less will the spread of fire be facilitated. The ordinary studded partitions should give place to walls of brick, or to special fire-resisting partitions. Floors may be of steel and concrete, protected beneath by fire-clay[1] or brick. Skirtings and architraves may be of cement. Metal lathing may be used instead of wood laths. Stairs may be of stone or concrete, and in other directions also wood may be superseded by an incombustible material.

The various kinds of wood differ largely, however, in their combustibility. The pines are the most dangerous, and the hard woods the least. A case is on record where an oak post was charred only to a depth of an inch, while a granite column close to it was burnt to powder.

If the combustible materials used in the construction of our buildings are reduced to a minimum, much will have been effected, but care must be taken that the incombustible materials which take their place are at least moderately fire-resisting. The instance just recorded shows clearly that all incombustible materials are not fire-*proof*. Granite crumbles away under great heat, limestones are nearly as bad, and even the best sandstones are poor in comparison with bricks and terra-cotta. Some concrete, again, is extremely brittle when raised to a high temperature, while unprotected iron and steel twist and bend. The ordinary lead or composition gas-pipes are a source of danger in fires, as they melt at a comparatively low temperature, and so let loose the inflammable gas upon the burning structure.

Nearly all household fires are caused by the faulty construction of the **fireplace** or its accessories. I know one room where two fires originated by burning ashes dropping through the joint between the front and back hearths upon the boarded ceiling immediately below; there was no trimmer arch under the hearth or any other protection. Sometimes floor-joists and the purlins of roofs pass directly into chimney-flues instead of being trimmed or supported on corbels. The great heat attained in many slow-combustion grates is another source of danger, and before one of these is fixed in an old house the hearth should always be raised, and the construction of the floor and of the hearth-supports be carefully examined. The proper construction of fireplaces and hearths will be more fully discussed in Chapter VI. of this Section.

To prevent the spread of fire from house to house in towns many somewhat stringent regulations are often enforced. The thickness of the **party-walls** is specified, and every party-wall must be carried through the roof[1] to a height of not less than 15 inches (measured at right angles to the slope of the roof),

[1] See Plate II.

the thickness of the wall to be not less than $8\frac{1}{2}$ inches. In London it is further enacted that "*every party-wall shall be carried up of the thickness aforesaid above any turret, dormer, lantern-light, or other erection of combustible materials fixed upon the roof or flat of any building within four feet from such party-wall, and shall extend at the least twelve inches higher and wider on each side than such erection, and every party-wall shall be carried up above any part of any roof opposite thereto, and within four feet therefrom.*"

A fire-resisting **roof** is a great barrier to the spread of fire, and in towns the flat roof of steel, fire-clay or brick, and concrete, covered with asphalt, is now frequently adopted, a somewhat similar method of construction being also used for sloping roofs covered with slates, copper, or other incombustible material.

Occasionally fires are caused by **lightning**, and every house in an exposed situation should be provided with one or more lightning-conductors.

Into the details of **fire-extinguishing apparatus** it is not proposed to enter, but attention may be drawn to the necessity of providing for large mansions a sufficient store of water for this purpose, with the necessary pipes and hydrants. In smaller houses portable extinguishing apparatus, sometimes known as "chemical fire-engines", will probably suffice; the small hand-grenades may also prove of great service.

CHAPTER II.

GROUND-WORKS.

The nature of building-sites from a medical point of view will be considered in a subsequent section. The architect's point of view may now be taken, and the first observation which the architect makes is that he is, unfortunately, very seldom consulted as to the site of a building; usually his employer comes to him and says: "Build me a house on this ground I have bought", and the architect must do what he can to make a habitable home, though the site be a bed of stiff clay or a swamp.

The **mould or "humus"** which usually forms the superficial layer of the soil, swarms with **living organisms.** Many of these are quite harmless to man,—indeed are Nature's scavengers, beneficial to man by reducing noxious organic matters to innocent inorganic pabulum for plants. Others, however, are pathogenic, and may cause disease in man, some when inhaled, some when received into the alimentary canal, and others only by actual inoculation. Miers and

Crosskey enumerate four conditions as necessary for their life and growth—*food* (organic carbon and nitrogen), *moisture*, *favourable temperature*, and *absence of inimical compounds.* The architect can only concern himself with the first two conditions, food and moisture. These he may remove from a building-site, the former by excavation and the latter by subsoil-drainage; he must also, by means of impervious ground-layers and perfect walls and drains, prevent their subsequent access.

The subject of ground-works will be treated under the following six heads:—1. Excavation and filling; 2. Subsoil-drainage; 3. Foundations; 4. Ground-layers; 5. Basement walls; and 6. Damp-courses.

1. *EXCAVATION AND FILLING.*

The practical details of excavation need not be discussed. Suffice it to say that all **humus and vegetation** ought to be removed from building-sites. This is an easy matter in many districts, where the surface-soil is only a few inches deep. In others it is not so easy, and in towns especially, where the level of the streets and buildings has been rising for centuries with accumulations of organic and other refuse, it may be a costly operation. Certainly there is not that imperative necessity to remove all humus or even "made" ground, if it is intended to cover the site with an absolutely impervious ground-layer, but the ground-layer *must be impervious.* But under any circumstances, soil which has been contaminated by excreta, or by leakage from drains and sewers, must be removed, and, if necessary, clean material deposited in its place.

A by-law of the London County Council, adopted in 1891, thus deals with **"made" ground**:—"*No house, building, or other erection shall be erected upon any site or portion of any site which shall have been filled up or covered with any material impregnated or mixed with any fæcal, animal, or vegetable matter, or which shall have been filled up or covered with dust, or slop, or other refuse, or in or upon which any such matter shall have been deposited, unless and until such matter or refuse shall have been properly removed, by excavation or otherwise, from such site. Any holes caused by such excavation must, if not used for a basement or cellar, be filled in with hard brick or dry rubbish, or concrete or other suitable material to be approved by the District Surveyor.*"

Frequently the lowest floor of a building is above the natural surface of the ground, and **filling** has to be adopted. Any clean gravel, sand, brick-rubbish, or loam will be satisfactory. Ashes are sometimes used—usually boiler-ashes, but objection is often taken to them because they harbour vermin. Coarse

concrete, however, does the same. Ordinary house-refuse and road-sweepings, which contain all manner of garbage, must not be used. Whatever kind of filling is adopted, it should be well consolidated, either by ramming, or, in the case of sand, by wetting.

2. *SUBSOIL-DRAINAGE.*

The greatest difficulty with which an architect has to contend in the ground-works of a building is that of the **ground-water** in low-lying lands. Springs on hillsides are easily dealt with, but the water which percolates through mud and gravel only a few feet below the surface of the ground, and rises and falls perhaps with the rise and fall of a neighbouring river or ditch, furnishes a more difficult problem. Nor is a site like this confined to plains; it may be found on the banks of most rivers, even in deep and narrow valleys.

A permanently high level of ground-water is dangerous to health, but fluctuating ground-water is much worse. It is one advantage of subsoil-drainage that it tends to prevent extreme rise of the water, and so lessen the degree of fluctuation.

The level of ground-water, it may be added, is always raised by capillarity. The amount of rise has been estimated at about 1 foot in sands, and 4 or 5 feet in clay and compact marl. The rise will be lessened in many soils by properly opening and draining them.

In many cases, it is a mere farce to talk of **draining the subsoil** to a depth of 6, 8, 10, or 12 feet; not until the ocean has been drained, can the level of the ground-water in many parts of these islands be permanently lowered. Where the sea has to be kept out by dikes and sluice-gates, it is of little use talking about subsoil-drainage. So difficult is it to render dwellings on such low-lying sites habitable, that by the London Building Act, 1894, the London County Council received power to prevent the erection of dwelling-houses upon them. In many elevated places, however, there are damp, even boggy, patches of ground, and these can easily be drained, because there is an outfall for the drain into the valleys below.

Not all ground requires underdrains: many rocky, sandy, and gravelly sites are sufficiently dry already. But every site must be judged by itself, as the nature of the ground varies greatly even in a short distance. It is better, however, to drain too much than too little. The drainage of **clay soils** renders them drier, and, by reducing the evaporation, warmer. **Sandy and gravelly soils** are naturally drier and warmer than clay; on account of their porosity water rapidly

sinks through them, and they contain a considerable volume of air. In these the fluctuation of ground-water and consequent exhalation of more or less impure ground-air are more to be feared than dampness.

Subsoil-drains are sometimes merely trenches cut to the necessary depth, and filled to the height of 2 or 3 feet with broken stone. The ground-water finds its way along these "rubble drains" (for so they are called) to the appointed outlet. Sometimes a small square drain is formed at the bottom of the trench with stones, or with tile bottom and brick sides and top. Pipes, however, permit the water to flow off more rapidly and are less liable to choke than stone drains. They may be either round or D-shaped, and should not be less than 3 inches in diameter. Unsocketed agricultural drain-pipes are often used, but there is some difficulty in keeping the ends of the pipes together, both horizontally and vertically. To obviate this, half collars 3 or 4 inches long are sometimes placed under the joints, or pipes with a socket on the lower half only are used. Ordinary socketed drain-pipes are also used, but with the joints left without cement or clay. The two last methods are the best. Whatever kind of pipe is used, the trench above should be filled with broken stone or screened gravel to the height of 1 or 2 feet.

In very wet and **loose sandy soils**, drains may carry away, little by little, considerable volumes of sand, and so endanger the ground and structures above. In extreme cases of this kind, subsoil-drains will be best omitted, and the money thus saved expended on a layer of asphalt with concrete bed over the site.

The depth of subsoil-drains should be as great as possible, but considerations of outfall and expense will frequently prevent the depth being more than 2 or 3 feet below the lowest floor. Where the drains are shallow, they should be closer together than is necessary when they are deep.

The distance apart of subsoil-drains must depend upon their depth, the quantity of water, and the nature of the ground. The stiffer the ground, the closer must they be. In stiff clay they should be laid every 3 or 4 yards, in loamy clay every 5 or 6 yards, while in sand and gravel they may be omitted altogether, or at the most a single drain may be laid around the outside of a building. In the other cases, however, it will usually be necessary to lay branch drains across the site in addition to the important drain encircling it.

The outlet for ground-water must be arranged according to circumstances. In many towns now, special "sewers" for surface-water and ground-water are provided, emptying into the nearest stream at various convenient points. In the country the subsoil-drains may be carried to the nearest stream or ditch, or, if there is sufficient fall, brought to the surface of the ground at some distance

from the house. Where, however, they must be connected with the sewage-conduits, they must be trapped from the house-drain as well as from the public sewer. The best method is to build an inspection-chamber by the side of one of the inspection-chambers on the sewage-drain, and to build the trap into the wall between the two, but well above the sewage-drain, so that sewage cannot pass into the trap. There is one obvious disadvantage in the connection of the subsoil-drains to the sewage-drains, and that is, that in dry weather the water in the trap may evaporate, and more or less foul air from the sewage-drains may then pass along the subsoil-drains, and find its way from them into the house. The risk is reduced by connecting some of the rainwater-drains to the inspection-chamber in which the trap is placed, but at the best the connection of subsoil-drains to sewage-drains cannot be recommended. On flat low-lying sites, it is better to raise the house on a terrace, and to drain the ground to as great a depth as possible by means of open ditches, into which the rainwater-drains from the house can be laid to discharge.

3. *FOUNDATIONS.*

A clay soil is good neither for the stability of the house nor for the health of its occupants. On hill-sides it has a tendency to slip, and in any situation it may shrink and crack in dry weather. A house may stand safely for many years on a clay soil, but an exceptionally dry season may then cause unsightly or even dangerous settlements and cracks, and the costly operation of under-pinning may be necessary in order to keep the house from falling, or (in extreme cases) parts of the house must be taken down and rebuilt. It is often said that no danger need be feared if the foundations are carried down to a depth of 3 feet from the surface of the ground, but experience teaches us that this depth is not always sufficient. The construction of a deep sewer near the house, for example, may drain some of the moisture from the clay, and produce the same effects as a prolonged drought. Exceptional care, therefore, is required in building on a clay soil.

It is impossible to lay down general rules for the safe bearing-power of **different kinds of ground.** Each site must be judged by itself, but, speaking roughly, it may be said that alluvial soil, or quicksand, ought not to be loaded with more than about 10 cwts. per sq. ft.; soft clay (near the surface), from 10 to 15; moist clay, from 15 to 30; compact clay, nearly dry, from 30 to 50; dry compact clay of considerable thickness, from 50 to 100; loose sand, from 20 to 30; compact sand, or gravel and sand, from 40 to 60; ditto, dry and prevented

from spreading, from 80 to 120, or even 150. The great point to be observed in designing foundations is so to arrange them that the pressure on the ground is equal throughout. Unequal loading (except on the firmest ground) gives rise to unequal settlement and probably cracks.

Foundations can be safely omitted only on exceptionally firm and uniform sites. Almost invariably some kind of foundation is required in order to distribute the weight of the superincumbent building over an area of ground sufficiently large to bear the weight without yielding. Foundations may be of timber, stone, brick, concrete, and even iron and steel.

Timber is seldom used nowadays for the foundations of buildings, except in the form of piles, and then only on soft ground of considerable depth.

Stone foundations are never used far from the quarries where the stone is obtained. In many localities, such as the flag-stone districts of East Lancashire and the West Riding of Yorkshire, they are still largely used, although even there they are being superseded by concrete. They may be obtained of any width up to 5 or 6 feet, and of any thickness up to about a foot. They are usually of strong coarse rag-stone, and not at all uniform in thickness. Sometimes two or more courses are employed, the second course narrower than the first, and breaking joint with it. No mortar is used either on their beds or joints. The chief objection to these footings is their longitudinal incohesiveness. (See No. 1, fig. 40.)

Brick footings are open to the same objection, and to the further one of transverse incohesiveness, especially where common-lime mortar is used in their construction. They consist of several courses of bricks, the lowest course being usually twice the breadth of the wall above, and the total height of the footings being not less than two-thirds of the breadth of the wall. They are narrowed as required by regular offsets (usually quarter-brick), as shown in fig. 39, which illustrates a brick and concrete foundation for an 18-inch wall. Five courses of bricks are here shown, having a total height of about 15 inches; four courses would meet the demands of most by-laws, but in the illustration the lowest projection is strengthened by being formed of two courses, an advantage where concrete is not used.

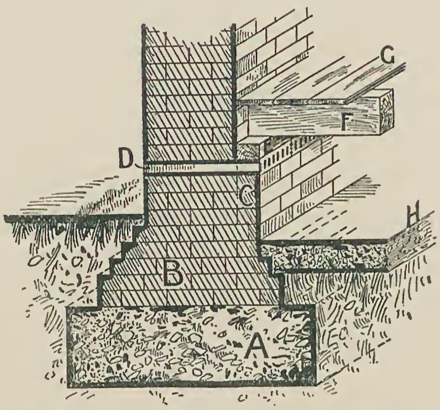


Fig. 39.—Brick and Concrete Foundation for 18-inch Wall.

A, concrete foundation, 4 ft. wide; B, brick footings; C, portion of footings built up to carry wall-plate E; D, stoneware ventilating damp-course 3 inches thick; E, wood wall-plate; F, wood floor-joist; G, floor-boards; H, concrete ground-layer.

On good ground, the brick footings twice the breadth of the wall above will

be sufficiently firm, as shown in fig. 41, p. 90. Where the ground is soft—whether natural or "made"—**a bed of concrete** not less than 12 inches wider than the brick footings is usually laid under them; its thickness should be not less than one-fourth its breadth, but will vary according to the nature of the ground, the weight of the building, and the quality of the concrete.

Brick footings as described above are made obligatory by the London Building Act, 1894, in all cases, except by special permission of the Council. Perhaps the by-law is on the whole a wise one, as concrete is so easily scamped, but there are many cases in which concrete alone would be more economical and more stable.

The ideal foundation, where great depth is unnecessary, is a solid bed of good concrete of uniform thickness, spread over the whole of the building-site and extending 2 or 3 feet beyond the walls on all sides. Its thickness must depend upon the nature of the ground and the weight of the building, but can seldom be less than 12 inches. Such a foundation is illustrated in No. 2, fig. 40. The concrete foundation with thinner ground-layer, shown in fig. 38, p. 66, is a cheaper modification of this. Over all a layer of asphalt should be spread, forming a damp-course both for floors and walls, and on it the walls may be built, and the basement floors, whether of wood blocks or concrete, may be laid.

Continuous concrete foundations and ground-layers cannot, however, always be adopted, as it is often necessary to carry some portion of the walls to a depth much below that of the basement floor.

The use of **iron and steel** in foundations can only be mentioned. Frequently the metal is in the form of steel rails embedded in concrete. Sometimes, as in the Ransome system, it consists of a series of twisted wires or rods embedded in the lowest part of the concrete to give transverse strength to the foundation. In either case, a stronger foundation can be obtained in less depth than when concrete alone is used.

Concrete for foundations was at one time generally made with a matrix of common lime, but nowadays hydraulic lime or Portland cement is almost invariably used. The latter is by far the stronger material, and good cement is more uniform in quality than good lime; hence the use of Portland cement is rapidly extending. There is, however, a great deal of rubbish sold as Portland cement—coarsely-ground and of a yellowish hue,—and this must be avoided. Plasterers, it may be said, regard it with especial favour; it is cheap, and great strength is not, they think, necessary in their work.

Portland cement should be *finely-ground*, *sound*, and of *sufficient strength.* The *fineness* of good cement is such that not more than 5 per cent will remain

on a sieve containing 2500 meshes in a square inch; the best cement will leave a residue of less than 5 per cent on a sieve with 5625 meshes in a square inch. *Soundness* means that the cement does not contain free lime or other ingredient which might cause the softening or cracking of the concrete some time after it had set. To ensure the slaking of the free lime, the cement should be spread in a perfectly dry place for a week or two before it is used, and occasionally turned over. The *strength* of cement is usually tested by its resistance to a pulling stress or tension; briquettes 1 inch or $1\frac{1}{2}$ inch square are made of neat cement, or of cement mixed with 3 parts (by weight) of sand, and kept one day in air, then placed in water. The neat briquettes are usually tested at the end of 7 days, and should give an average tensile strength of 350 or 400 lbs. per sq. inch; and the briquettes of cement and sand should have a strength of about 120 lbs. per sq. inch at 7 days, and 200 lbs. at 28 days.

The bulk of concrete, however, consists of other materials, known as the **aggregate**, which may be gravel, broken stone or brick, coke-breeze, &c., and sand. For foundations the hardest materials should be used, such as gravel and hard broken stone. In London, Thames ballast is largely used, but a better (because cleaner) material is the broken and screened shingle which the Great Eastern Railway Company prepares at Lowestoft. The aggregate should be passed through a screen with 3-inch meshes, and should be free from clay, organic refuse, and other impurities.

Sand is almost invariably used in the making of concrete. A considerable quantity is present in Thames ballast, and no additional quantity is required when this is the aggregate employed. A certain amount of sand is made in breaking stone, quite sufficient, indeed, except when the stone is extremely hard; soft stone often yields too much sand, and some of it must be screened out if strong concrete is required. The volume of sand in concrete for foundations should not exceed one and a half or, at most, two volumes of the cement; if more than this be present in an aggregate, part should be screened out. Undoubtedly the best plan is to screen *all* the sand from the aggregate, then the cement, sand, and aggregate can each be accurately measured; but the builder will have to be closely watched or the plan will not be carried out. All sand used for concrete should be clean, sharp, coarse, angular, and durable; pit-sand is usually much improved by washing. Street-scrapings are not sand in the estimation of an architect or magistrate, whatever they may be in that of a jerry-builder.

The proportions of cement, sand, and aggregate used in concrete for foundations vary from $1 + 1 + 4$ to $1 + 2 + 8$ or even 10. Good work may be ensured

by a mixture of *one* part of cement, *one and a half* parts of sand, and *five* parts of broken stone or gravel. When such a mixture is specified, the builder will frequently argue that it is a 1 to $6\frac{1}{2}$ mixture, and will measure the sand and stone together in a box $6\frac{1}{2}$ times the volume of a bag of cement. This is advantageous to him, for the sand merely occupies the interstices in the broken stone, and his mixture really contains *one* part of cement, *two* or *two and a half* of sand, and *six and a half* of broken stone; or, to put it another way, the builder's concrete will contain one-fourth less cement than concrete made according to the specification. Perhaps for ordinary foundations—especially in small buildings where the constant supervision of a clerk-of-works cannot be afforded—the wisest method is to specify that the gravel or broken stone shall be measured with the sand naturally contained in it or made in breaking it, and that no more sand must be added.

The **ingredients** of concrete should always be **accurately measured.** A full bag of cement weighing 2 cwts. contains about $2\frac{2}{3}$ cub. ft., and boxes for the aggregate are often made some multiple of this: thus, the box to contain five parts of aggregate would contain $13\frac{1}{3}$ cub. ft., and might measure $4' \ 7'' \times 2' \ 6'' \times 1' \ 4''$. It should be ascertained, however, that the bag does contain 2 cwts.; frequently a bag of cement weighs only 200 lbs., and half-bags are common.

The **mixing** of concrete is usually done by labourers on a platform of wood, but for large works a machine is employed. In hand-mixing, the ingredients should be turned over twice dry, sprinkled with *clean fresh water* while being turned over a third time, and finally turned over a fourth time. The mixture should at once be deposited in position, and moderately pounded. Foundations more than about 15 inches thick should be deposited in two or more layers, unless several gangs of men are employed in mixing and depositing the concrete.

4. *GROUND-LAYERS.*

The pores of the ground are filled with water or air. The water may be reduced by drainage, but the ground-air will be increased by it. Sandy soils may contain air to the extent of 40 or even 50 per cent of their volume.

Ground-air is dangerous in more ways than one: it contains a relatively large proportion of carbonic acid, the proportion increasing with the distance from the surface. At Dresden, Flach found the ground-air to contain 3 per cent of the gas at a depth of 2 metres, and no less than 8 per cent at a depth of 6 metres; even 3 per cent is about one hundred times as much as that contained in normal atmospheric air. When we remember that air containing

$2\frac{1}{2}$ per cent will extinguish a candle, the dangerous character of ground-air is easily understood.

A further and greater danger is that ground-air may contain other gases, such as ammonium sulphide and marsh-gas, due to the fermentation and decomposition of organic matters, and, in towns especially, may be charged with sewer-air and with coal-gas from leaking mains. The explosive character of air mixed with coal-gas is not its only danger; it may produce headache, nausea, and more distressing symptoms, while its presence may be unsuspected, as the gas may be deodorized by passing through the soil.

And finally, ground-air may contain the spores of pathogenic bacteria which have found a suitable nidus in the soil.

The movement of ground-air is a well-ascertained fact, and is influenced by wind and rain, by the rise and fall of ground-water, and by changes of temperature and barometric pressure.

A warm house tends to draw the cool damp ground-air into it, especially when the external temperature is low. The explosions of coal-gas in houses which have no connections with the gas-mains are evidence in proof. Hence the necessity of **covering the site of a house** with a layer which shall be impervious alike to moisture and to gases, even under pressure.

"*The site of every house or building shall be covered with a layer of good concrete, at least six inches thick, and smoothed on the upper surface.*" Such is the by-law in force in London. In many towns a layer of asphalt may be used instead of concrete. If good results are desired, both concrete and asphalt should be used, as concrete alone is not impervious, and asphalt is all the better for a firm and level bed. Examples of ground-layers are given in figs. 38 to 42, and also in Plates II. and III.

Concrete for ground-layers need not be as strong as that for foundations, but should be more solid; it must therefore contain more sand in proportion to the gravel or other broken material. Coke-breeze is not a good material for the aggregate; harder and more impervious material is better, such as gravel, broken stone, slag, hard brick, even broken flints. The aggregate, too, should be of smaller size; all should pass a screen with $1\frac{1}{4}$-inch or $1\frac{1}{2}$-inch square meshes. The sand may be finer than that used for foundations. The proportions may be 1 cement + 2 sand + 4 aggregate, or 1 cement + $2\frac{1}{2}$ sand + 5 aggregate. The wet concrete should be well pounded, either with a light rammer or the back of a spade, and trowelled to a smooth surface. The last operation reduces considerably the perviousness of the concrete, and a further reduction may be effected by covering the layer with a coat, however thin, of neat cement, or even of lime-whiting.

Professor Tichborne found the **relative porosity** of certain mortars and asphalt to be as follows:—1. Common lime-mortar (1 lime + 2 sand), 100; 2. plaster of Paris, 75; 3. Roman cement, 25; 4. Portland cement, 10; 5. asphalt, 0. The advantage of asphalt ground-layers is evident from these figures. Portland cement, indeed, approaches asphalt, but Portland cement, it must be remembered, is not concrete: admixture with sand and other material increases its permeability, however carefully the admixture may be made.

Asphalt is a generic name, comprising many varieties of material, good, bad, and indifferent. It may mean the natural bituminous limestone found at Pyrimont Seyssel, Limmer and Vorwohle, Val de Travers, and other places, or more commonly, a compound of any one of these with more bitumen and sand. It is also used to designate a number of compounds, of which coal-tar pitch is the chief ingredient, but which may contain oil, sand, quicklime, tar, and other materials. These may be called "artificial asphalts" to distinguish them from the "natural asphalts".

Natural asphalts are undoubtedly more durable and trustworthy than the others, but they are also more expensive. The artificial "British" asphalt can be laid at one-half the cost of natural asphalt. For good work, however, one of the natural asphalts should be used. The preparation and laying of the material require considerable care, and ought always to be done by skilled men. An iron caldron is heated and gradually filled with small pieces of "mastic" asphalt, and a small proportion of natural bitumen to act as a flux, the mixture being stirred at intervals. In three or four hours from lighting the fire the mixture will be ready for use. Great care must be taken that the concrete bed is thoroughly dry, as otherwise the moisture will form steam and burst through the asphalt. To ensure the dryness of the bed, it should be allowed to stand for two or three weeks (more if possible), and hot cinders should be spread on it before the asphalt is laid. After the removal of the cinders, the caldron man takes a quantity of the viscous asphalt from the caldron, in a pail or ladle, and empties it on the bed; here the spreader at once commences to work it with a wooden rubber, carefully compressing it to the specified thickness, which need not be more, for ordinary work, than half an inch. Wood laths of the same thickness as the proposed coat of asphalt, are placed on the concrete to serve as guides in spreading the layer. Particular care must be observed that the junction between each new spreading and the work already executed is carefully made. In very wet situations, two $\frac{3}{8}$-inch or $\frac{1}{2}$-inch layers must be used instead of the single layer, if perfect watertightness be desired.

The great objection to **artificial asphalts** is that they become very soft in

hot weather, and are therefore apt to " run ", and even to allow pieces of grit or sand to sink through them. They may, however, be used with advantage in buildings for which the natural asphalts are too costly. An artificial asphalt is better than no asphalt at all. They are chiefly mixtures of pitch and creosote oil, boiled in a caldron, a variable quantity of fine hot dry sand being subsequently added. Too much oil renders the asphalt soft and liable to run in hot weather, while excess of sand renders it brittle—especially in cold weather,—and may lead to cracks or even general perviousness. The mixtures are usually laid in a more liquid state than the natural asphalts. The so-called " British" asphalt is a well-known variety. Briggs's "Tenax" and White's "Hygeian Rock" building-compositions are better materials of similar nature, but supplied in powder ready for the caldron.

The various kinds of **floor-surfaces** suitable for basements will be described hereafter.

5. *BASEMENT WALLS.*

Damp and ground-air may not only rise through the floor of a house; they may find entrance through the **basement walls.** It is of little use covering the site with an impervious layer of asphalt if the walls be left pervious and in contact with the ground. Hence the necessity either of surrounding the basement with an open area, or of building the walls of such materials and in such a manner as to prevent the ingress of moisture and air.

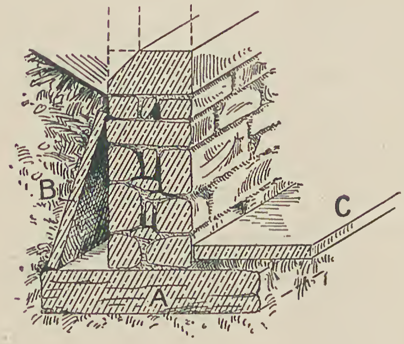
Many an old house nestling into a hillside has nothing to protect its back wall from damp but a trench full of rubble stones with a stone drain at the bottom. For a time such a **rubble-trench** may be of service, but it is sure tc choke at last, and then it ceases to be any protection.

Undoubtedly **an open area,** sufficiently wide to admit of easy cleansing, and extending to a depth of about 6 inches below the damp-course under the basement floor, is an effectual preventative of ground-air and ground-damp in walls. The bottom of the area should be formed of concrete, with asphalt similar to that on the ground-layer and walls; if good natural asphalt with a gritted surface is used, no further covering is required. This arrangement is illustrated in fig. 38, page 66. In very wet ground it will be advantageous to continue the asphalt layer through the area wall and up the back of it as shown in the figure; the house will then stand in a dry waterproof dam.

Where space for an open area cannot be afforded, a **dry area,** or **"air-drain"** (as it is sometimes termed), may be formed with sloping flags, or with an

additional wall of brick or stone. No. 1, fig. 40, shows a bad example of a basement surrounded by a dry area formed with flags; the window-sill and the sloping ground conduct the rain-water to the upper edge of the flagging and so into the wall and area; there is no damp-course to the wall, and the floor is formed of flags without any underlying bed of concrete or layer of asphalt.

Of course a dry area may be constructed of stone without the defects depicted in the last figure, but it is a better plan to form the area by means of an additional thin wall of brick or stone, the wall and area being covered at the surface of the ground with weathered stone, concrete, or bricks, which must be jointed and pointed with cement-mortar so as to prevent the ingress of surface-water. Examples of dry areas formed with an additional brick wall are shown in Nos. 2 and 3, fig. 40. The wider the area is made the better; two horizontal damp-courses should be laid in the wall, as at B and C in No. 2. Small openings for ventilating the area should be provided at intervals, as shown at E E in No. 3.



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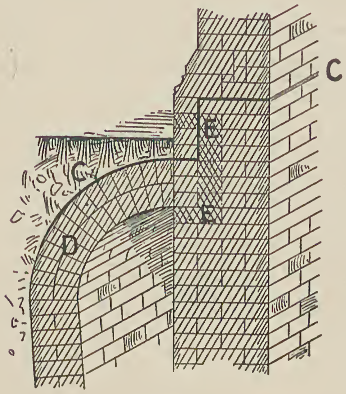

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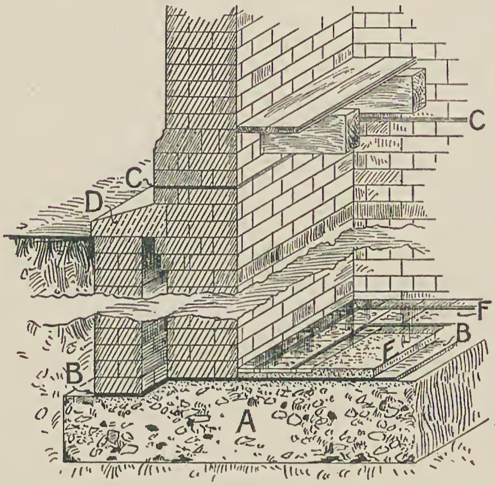


No. 2.

Fig. 40.—Dry Areas.

No. 1, Bad example of stone wall and dry area. A, stone foundation; B, flags forming area; C, flags forming floor. No. 2, Dry area formed with brickwork. A, concrete foundation and ground-layer; B, lower asphalt damp-course; C, upper asphalt damp-course; D, stone coping over area; E, concrete floor-surface; F, tile border on cement mortar. No. 3, Dry area formed with brick wall and arch. C, upper asphalt damp-course; D, brick arch over area; E E, ventilating-shaft from area.

Closely akin to a dry area is a **hollow wall.** In this the air-space or cavity, usually 2½ or 3 inches wide, is formed within the main wall itself and not outside it as in the previous case. The arrangement is illustrated in

fig. 41, but it cannot be recommended, as part of the wall is left unprotected, and in very wet ground the water will penetrate to the cavity and soak into the inner lining of brickwork.

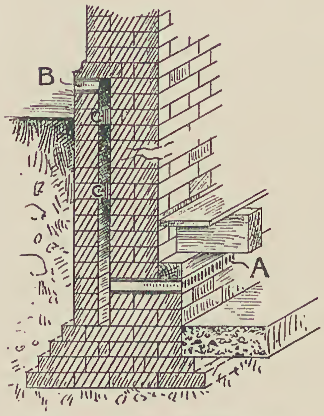


Fig. 41.—Hollow Basement Wall.

A, lower stoneware ventilating damp-course; B, upper stoneware ventilating damp-course; C C, bonding-blocks.

Neither the hollow wall nor the dry area is a satisfactory method of construction. In each there is a narrow cavity, well-nigh impossible of access to the householder, but capable of harbouring vermin and facilitating their movements, and while both are of some use in retarding the ingress of ordinary damp, they assist rather than impede the entrance of ground-air and water. Where an open area of sufficient width cannot be formed, the most sanitary construction is a **solid wall,** rendered impervious alike to moisture and to air.

As most bricks and stones are very far from being impervious, it follows that a wall built of these materials alone—however well it may be constructed—cannot be absolutely waterproof. Certainly a wall built of good bricks in **Portland-cement mortar** (*one* part of cement to *two* of sand) and well grouted with neat cement, *ought* to be practically impervious, especially if a cavity (which need not be more than $\frac{1}{2}$ inch or $\frac{3}{4}$ inch wide) be left in the body of the wall and run with grout; but such is the carelessness of the ordinary bricklayer that it is almost certain it will not be. A coat of Portland-cement mortar (1 cement + 1 sand) carefully applied to the exterior of the wall after the joints have been well raked out, is a safer protection than the grouted cavity.

A method sometimes adopted is to build a vertical layer of **roofing-slates** between two skins of brickwork, but the process is tedious and expensive.

A better method is to form a **narrow cavity,** $\frac{1}{2}$ inch or $\frac{3}{4}$ inch wide, in the body of the wall, and run it full every two or three courses, with molten **asphalt or waterproof composition.** Iron ties dipped in the composition must be laid across the cavity at intervals to bond the two parts of the wall together. Great care must be taken that the cavity is kept free from mortar, &c.; this can best be done by means of a thin board built into the wall to form the cavity and lifted out every two or three courses, when the cavity can be at once filled with asphalt. In building walls of this kind, it is better that the mortar in the brickwork should not extend quite up to the cavity, in order that the composition can key into the joints. For convenience in filling the cavity, one skin of the brickwork is often carried one course higher than the

other, and a piece of sheet-iron resting on wedge-shaped chairs is placed on the lower brickwork to direct the liquid into the cavity. Or a spouted utensil may be used for pouring the liquid. The cavity must be quite free from water when the molten composition is run in.

For waterproofing walls in this way, some kind of artificial asphalt is usually employed. The mixture of pitch, oil, sand, &c., made by rule of thumb by the builder or one of his labourers, is far from reliable, unless very careful supervision be exercised. More satisfaction will be given by the use of one of the well-known compositions specially made for the purpose, such as the "Hygeian Rock" and "Tenax" compositions, and "Sub-aqueous Asphalt". Sometimes one of the natural asphalts,—Limmer, Seyssel, &c.,—is used.

One disadvantage of this method of construction is that the outer portion of the wall is not protected against the damp. In order that this portion may be as small as possible, the outer skin of the wall should be only a half-brick thick. A horizontal damp-course, extending over this outer skin, must always be laid a few inches above the surface of the external ground. A second disadvantage is that no inspection of the vertical damp-course is possible, and consequently defects—which may occur through carelessness or the presence of small pieces of mortar or brick, or water—may not be discovered till damp has struck quite through the wall, perhaps some time after the house is occupied.

The only way of making the whole of a wall in wet ground quite dry is to spread a **waterproof coat on the outside of the wall.** For cottages and other buildings where economy is a paramount consideration, a very thin mixture of boiled pitch and oil may be applied to the wall with a brush, but this method has little to recommend it save its cheapness. The best method is to spread on the wall one or two layers of natural asphalt, carefully connected with the horizontal damp-course as shown in fig. 42. In connecting horizontal and vertical damp-courses a triangular fillet is usually employed as at D. The top of the vertical asphalt may be finished by tucking it into a joint above the ground to the depth of about an inch, or may be connected with a second horizontal damp-course at that level. Where the exposure of the vertical coat of asphalt

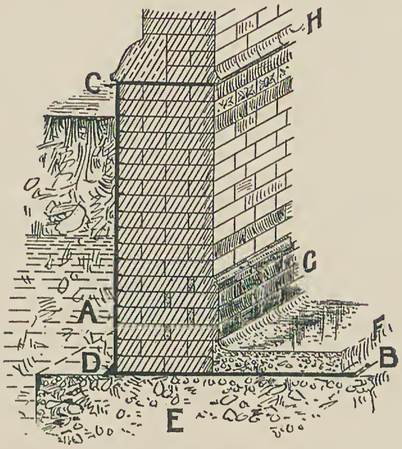


Fig. 42.—External Vertical Damp-course of Natural Asphalt.

A, vertical asphalt damp-course; B, lower horizontal damp-course; C, upper horizontal damp-course; D, asphalt fillet; E, concrete foundation and ground-layer; F, concrete floor finished with terrazzo, and rounded to meet plinth; G, glazed brick plinth; H, glazed brick capping to dado.

above the ground is objectionable, recourse may be had to the arrangement shown in No. 3, fig. 40, where the asphalt is faced outside with a $4\frac{1}{2}$-inch skin of brickwork.

Before laying a vertical damp-course of natural asphalt, the wall should be dried by means of coke-fires and the joints raked out to the depth of an inch. The joints are then filled with mastic asphalt, and afterwards the proper layer is spread upon the wall. Sometimes a single layer $\frac{1}{2}$-inch thick is used, but in wet situations two $\frac{3}{8}$-inch layers are necessary.

It not unfrequently happens that a **basement or cellar** is required to extend below the permanent level of the ground-water, or **below the flood-level** of an adjacent river. It is then necessary to cover the ground-layer and walls with a sheet of asphalt absolutely flawless and continuous, and so arranged as to resist the pressure of the water. Fig. 42 exhibits a simple method of doing this; the horizontal coat is spread either on a level concrete bed or when the walls have been built to the level of the ground-layer, and on it the upper walls are built and a sufficient weight of concrete is deposited over the ground-layer to resist the upward pressure of the water. In exceptional places, where the pressure is great, the concrete ground-layer may be formed with a concave surface (as shown in fig. 43), on which the asphalt is laid. An inverted arch of one or more $4\frac{1}{2}$-inch rings of brickwork in cement-mortar may then be built on the asphalt and finished above with concrete; or the brick arch may be omitted and concrete alone be trusted to resist the upward stress.

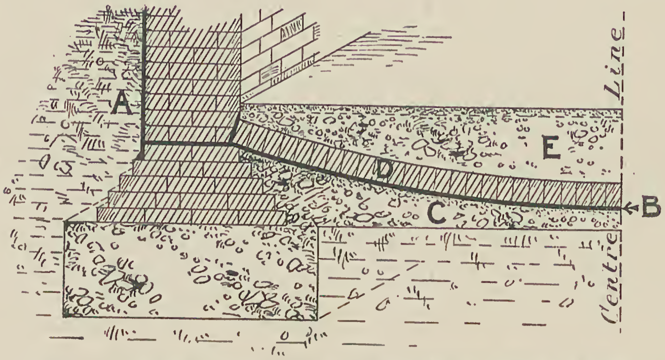


Fig. 43.—Asphalted Floor and Wall to resist considerable Pressure of Water.
A, vertical asphalt damp-course; B, lower horizontal damp-course; C, concrete bed to receive asphalt; D, inverted brick arch; E, concrete filling and floor.

In the case of cellars sunk below the permanent level of ground-water and therefore below the drainage-level, the formation of an open area is obviously unwise, as no outlet can be obtained for the rain-water which may find its way into it. The best mode of construction in such cases is the solid wall asphalted outside, even though it be necessary to construct a temporary coffer-dam in order to keep out the water during the progress of the work. Only in the most exceptional circumstances, however, should cellars be constructed below the level of the ground-water. It is always more conducive to health to raise a house-

floor well out of the ground, than to sink it below the ground, and it is usually cheaper.

Where ordinary open areas, dry areas, and cavity-walls are adopted, provision must always be made for **ventilating and draining** them; otherwise they will prove of little or no use.

The **materials** used in the walls of basements, especially in those walls which are in actual contact with the ground, are often of the commonest kind. Anything is good enough to be buried is the builder's thought. Certainly where an external asphalt layer is adopted, there is not so great a necessity for impervious and non-absorbent materials, but as a general rule it may be said that materials exposed to damp, as in basement walls, should be hard, dense, and durable. Soft porous bricks and coarse friable stone are out of place in such situations. The nature and properties of building-materials will be discussed a little more fully in the next chapter; suffice it now to say that the bricks should be hard and dense—blue Staffordshire bricks for the best work,—the stone close-grained, and the mortar of the best. It is a good plan to use hydraulic mortar in all basement walls, either Lias lime, or (better) Portland cement. Concrete composed of Portland cement, sand, and hard, well-broken aggregate, mixed in proper proportions $(1 + 2 + 3$ or $4)$, is an excellent material.

6. *DAMP-COURSES.*

The word "**damp-course**" is usually applied to a *horizontal* damp-resisting course forming part of the structure of a wall. The building-regulations of most large towns and cities require such a course to be laid in all walls of buildings. The London County Council's by-laws state that it must be "at a level of not less than six inches below the level of the lowest floor". Opinions may differ as to the necessity of placing the damp-course six inches below the floor-level, where a solid floor is adopted as in figs. 38, 40 (No. 2), and 42, but where an ordinary joisted and boarded wood floor is desired, the depth of six inches will probably be exceeded, as in figs. 39 and 41.

For walls in contact with the ground, however, one damp-course is not sufficient. Reference to fig. 41 will make it clear that the outer skin of the hollow wall there shown will absorb moisture from the ground; and this moisture will rise by capillarity into the solid wall above the cavity and probably make itself visible on the plaster and wall-paper, unless its upward progress is stopped by a damp-course at B. This upper damp-course may be laid over the outer portion only of the wall, but in most cases it is a cheese-paring

economy not to cover the inner portion as well. For the necessity of two damp-courses, see also Nos. 2 and 3, fig. 40.

Many different kinds of materials and contrivances have been used for damp-courses. Good **asphalt** is one of the best, and has the great advantage of forming a continuous sheet with the asphalt ground-layer. Nothing further need be said about the ordinary methods of using natural and artificial asphalts, as they have already been described at some length with reference to ground-layers and vertical damp-courses, but attention may be drawn to one variety of asphalt damp-course, known as Callender's **Pure Bitumen Damp-course,** which consists of sheets of bitumen supplied in lengths of 24 feet, and in various widths. To lay the damp-course, the sheets are simply unrolled on the wall and the several lengths joined together by means of a hot iron. The material is not a felt, and is guaranteed free from coal-tar and pitch.

Somewhat akin to asphalt is **bituminous felt,** or, as it is sometimes called, **fibrous asphalt,** which can be obtained in sheets of various widths from $4\frac{1}{2}$ inches upwards. The sheets are laid to overlap about 2 inches at the joints, or two thicknesses are used, breaking joint. These sheets are very convenient and economical, especially for works in the country, and have the advantage of not cracking when any settlement of the building takes place. Doubts about the durability of the material are sometimes expressed, but with what reason I cannot say.

A layer of good **Portland-cement mortar** (1 cement + 1 sand) is sometimes used, but cannot be recommended, as it is not entirely impervious at the best, and cracks with any settlement of the building

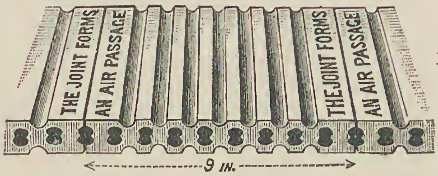
Two courses of strong **slates,** thoroughly bedded in cement-mortar and laid to break joint, are a better remedy, although they also are liable to fracture, and leave a thick unsightly joint in the face of the stonework or brickwork, unless a bed is sunk to receive them.

Sheet-lead was formerly much used for damp-courses and answered the purpose admirably, but on account of its cost it is now seldom adopted except in thin sheets coated thickly with bitumen on both sides.

Two or three courses of **blue Staffordshire bricks** with the vertical joints left open are economical, and, above ground, effective.

Where the lowest floor of a house is of wood and above the ground or area outside, the best material is the **stoneware ventilating damp-course,** shown in fig. 44, and also in fig. 39, p. 82. The slabs are perforated, and may be obtained in thicknesses from $1\frac{1}{2}$ to 3 inches, and in widths from $4\frac{1}{2}$ to 18 inches and upwards; the length of the slabs is usually 9 inches. Besides being proof

against damp, they afford continuous and constant ventilation to the space below the floor, and so help to prevent the decay of the wood. Special slabs are made for salient angles.



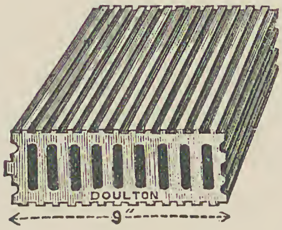


Fig. 44.—Vitrified Stoneware Ventilating Damp-course, 1½, 2½, and 3 inches thick, with Open Joints.

No. 1, "Broomhall" with open joints. No. 2, Doulton's with tongue-and-groove joints.

CHAPTER III.

EXTERNAL WALLS.

The walls of houses are designed for a twofold purpose, namely, **protection and support,** or, to put it more fully, to protect the occupants and contents of the houses from those external influences which might act injuriously upon them, and to provide adequate support for floors and roof.

It is only in lofty or heavy-laden buildings that the question of support needs much consideration. For ordinary brick or stone houses, a wall that is weather-proof will be amply strong enough to carry all the weight which will be put upon it. In exposed situations especially, the question of shelter or protection is practically the only one that requires attention. To fulfil this primary purpose, a wall must be proof against wind and rain, a bad conductor of heat, and durable.

The thickness of the walls has a considerable effect on the dryness and even temperature of a house, but the nature and quality of the materials constituting the walls, and the manner in which they are put together, are also of great importance. The thickness of a wall, in fact, must be varied according to the nature and quality of the materials and the manner of construction. Thus, rubble walls in which the stones are not laid in horizontal beds or courses, are usually specified to be one-third thicker than brick walls or squared-stone walls of the same height.

In order to put some check on the jerry-builder's love of flimsiness, **building-regulations,** prescribing *inter alia* the thickness of walls for buildings of various

heights, have been adopted in all towns and cities. The regulations in force in London are somewhat intricate, but, speaking broadly, two-storied houses not more than 25 feet high must have walls not less than $8\frac{1}{2}$ inches thick for the whole height, and three-storied houses must have walls $8\frac{1}{2}$ inches thick for the highest story, and not less than 13 inches for the others. Walls from 40 to 50 feet high must be not less than $8\frac{1}{2}$ inches thick for the top story, $17\frac{1}{2}$ inches for the lowest, and 13 inches between. Walls from 50 to 60 feet high must be not less than $17\frac{1}{2}$ inches thick for the two lowest stories, and 13 inches above. If the walls are unsupported by cross-walls, except at considerable distances, the thickness must be somewhat increased. See Plate II., A.

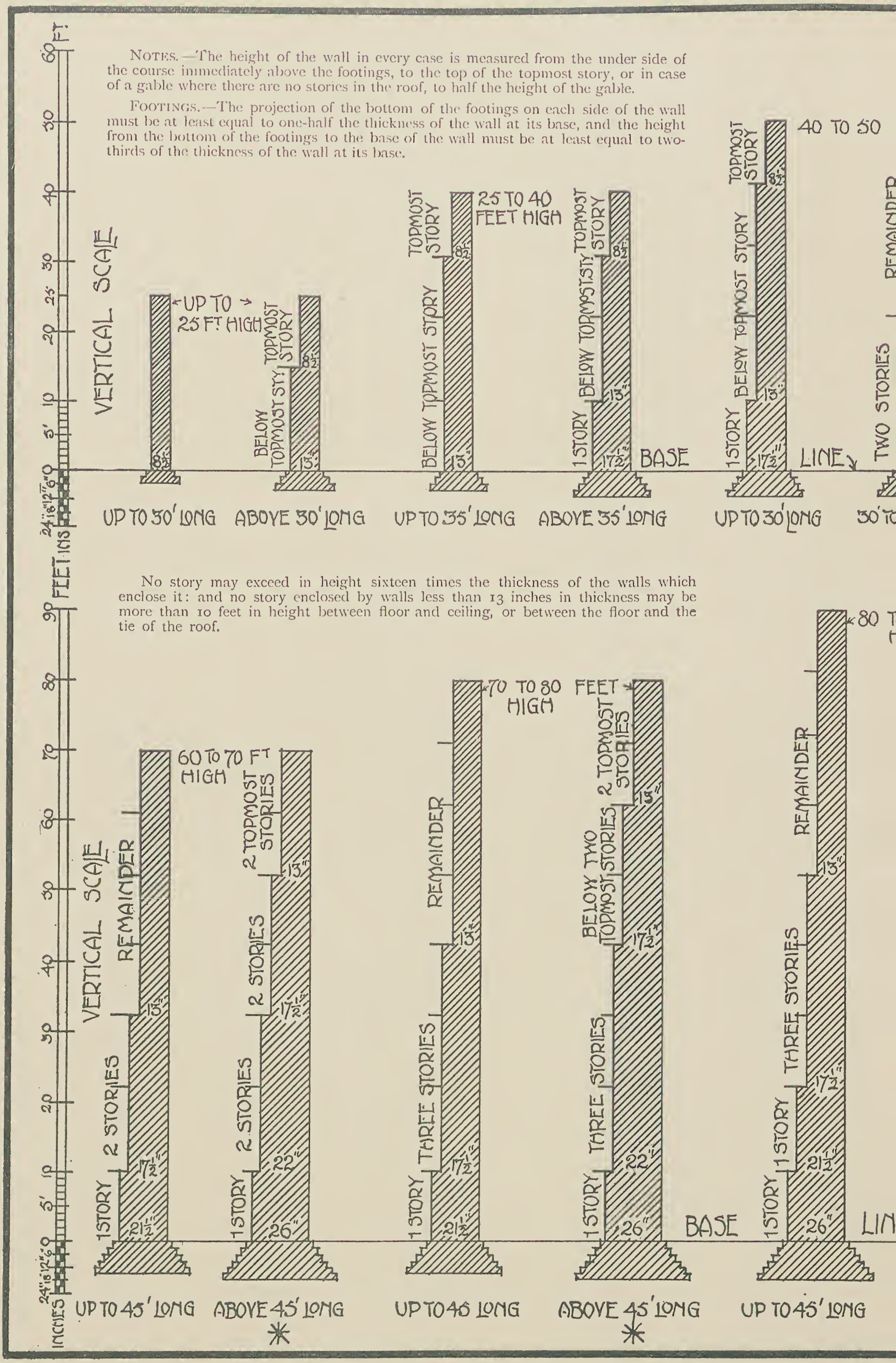
The thicknesses just given are for walls built of brick or squared stone, or of Portland-cement concrete properly laid in courses. Random rubble-walls must be one-third thicker. In the case of hollow walls, there must be a wall on one side of the cavity of the full thickness prescribed by the Act.

Of course these regulations are for London only. The by-laws of other cities and towns differ considerably, but in a work of this kind it would be useless attempting to note the different regulations, even of the largest towns. The by-laws in force in any locality must be carefully studied by the architect and builder before plans are drawn or work begun for any houses there. It will often, however, be advisable to adopt a greater thickness than the *minimum* allowed by the regulations; certainly an ordinary brick wall $8\frac{1}{2}$ or 9 inches thick is little protection against cold and rain, especially in exposed situations.

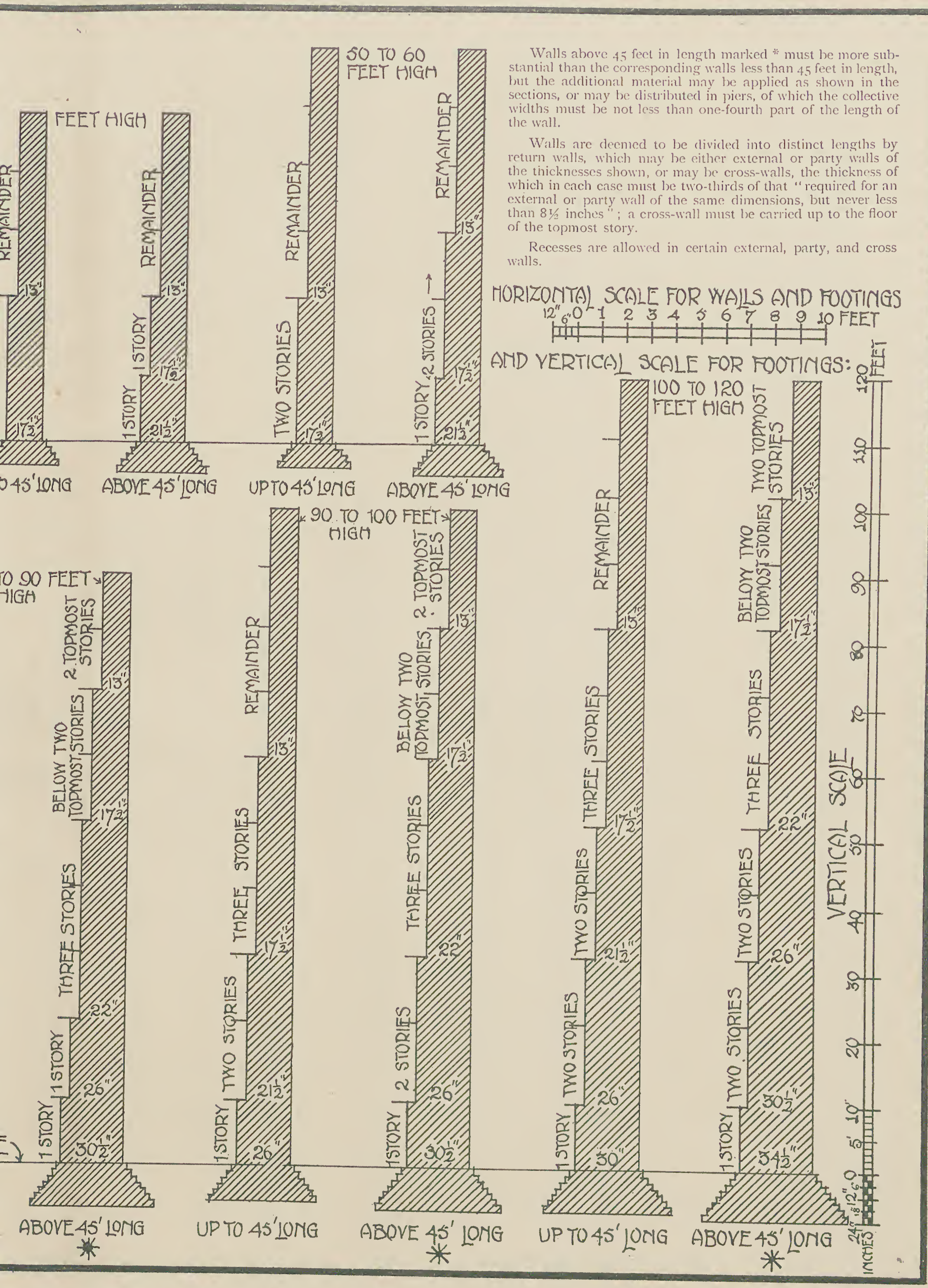
The walls of houses are constructed of various **materials**—stone, brick, terra-cotta, concrete, mortar, wood, tiles, plaster, &c. But in most large towns and cities, the authorities insist on the walls being built of "brick, stone, or other hard and incombustible substances"; wood, valuable though it is as a non-conductor of heat, is too inflammable to be allowed for so important a part of a building as the walls. Of every kind of material there are different qualities—good, bad, and indifferent; and the durability, healthfulness, and comfort of a house depend largely on the proper selection of the several materials. Perhaps there is no part of an architect's work more difficult or disagreeable than to decide as to the acceptance or rejection of materials which the builder has brought to the building-site.

It will be impossible here to enter with any degree of fulness into the varieties of every kind of material used in the construction of walls, but an attempt will be made to give briefly some useful information on the subject.

One general rule may be laid down:—Before adopting any particular material in a building, take care to examine its behaviour in one or more buildings in the



EXTERNAL AND PARTY WALLS
LONDON BUILDING ACT (



Walls above 45 feet in length marked * must be more substantial than the corresponding walls less than 45 feet in length, but the additional material may be applied as shown in the sections, or may be distributed in piers, of which the collective widths must be not less than one-fourth part of the length of the wall.

Walls are deemed to be divided into distinct lengths by return walls, which may be either external or party walls of the thicknesses shown, or may be cross-walls, the thickness of which in each case must be two-thirds of that "required for an external or party wall of the same dimensions, but never less than 8½ inches"; a cross-wall must be carried up to the floor of the topmost story.

Recesses are allowed in certain external, party, and cross walls.

AND FOOTINGS PRESCRIBED BY THE
894) FOR DOMESTIC BUILDINGS.

immediate neighbourhood. This perhaps is particularly applicable to stone and brick, but it will prove useful in other cases too.

And a second rule is:—Be chary of adopting new materials, or of using known materials in localities where they have not before been adopted. Had Sir Gilbert Scott acted upon this rule, he would not have specified magnesian limestone for the beautiful church at Haley Hill, in smoky Halifax, nor would the vicar and churchwardens have been called upon to "restore" the church within a few decades of its erection.

But while bearing this rule in mind, we must not run to the opposite extreme and resolutely ignore all new materials or new adaptations of old ones:

> "Be not the first by whom the new are tried,
> Nor yet the last to lay the old aside".

1. *STONE.*

Stone is first of building-materials in order and in rank. But there are many varieties and many qualities, from green jasper and peach-blossom marble to such a stone as the spiteful bishop dreaded for his tomb,—

> "Stone—
> Gritstone, a-crumble! clammy squares which sweat
> As if the corpse they keep were oozing through!"

The principal varieties may be roughly classified as *granites*, *marbles*, *limestones*, and *sandstones*. Other kinds of stone, such as slates, flints, and various igneous rocks, are also used in the construction of walls, but chiefly in the immediate neighbourhood of the quarry or pit where they are obtained.

The use of **granite** and other igneous rocks in buildings, except in the neighbourhood of the quarries, is almost invariably restricted to ornamental features. The best granites are extremely hard, non-absorbent, and durable. In consequence of their hardness and the remoteness of the quarries, the cost of polished granite in our towns is invariably high. One disadvantage of the material is its cracking and crumbling away under heat.

Marbles, like granites, are chiefly used for ornamental purposes. They are hard, crystalline limestones, often beautifully figured, and capable of taking a high polish. The best varieties are too expensive for general purposes of construction, and, as in the case of igneous rocks, the other kinds are seldom used far from the quarries.

Limestones are an important class. The best-known varieties are "Bath

stone" and Portland stone, the former (speaking generally) being quite unsuitable for outdoor use in the smoky air of towns, while the best beds of the latter have withstood the atmosphere of London with remarkable success. To some persons, the peculiar blackness and whiteness so characteristic of Portland stone buildings—for example, St. Paul's—are objectionable, but after all, these are better than the all-pervading Stygian blackness of sandstone as exemplified in our northern towns, say in the town-halls of Leeds, Halifax, and Manchester.

Other well-known oolitic limestones are obtained from Doulting (Somersetshire), Painswick (Gloucestershire), and Ancaster (Lincolnshire), and a hard and most durable carboniferous limestone is quarried at Hopton Wood, near Wirksworth, in Derbyshire. Magnesian limestones occur at Mansfield in Nottinghamshire, Anston in S. Yorkshire, and Bolsover Moor, near Chesterfield, in Derbyshire.

The **sandstones** used in building are obtained chiefly from the Triassic, Permian, and Carboniferous formations. The *Triassic* rocks are frequently of a red colour, and are not noted for durability; they are quarried in Shropshire, Staffordshire, Cheshire, and some other counties.

Many of the *Permian* sandstones are also red, such as those quarried in the neighbourhood of Penrith, and at Corsehill and Lockerbie in Dumfries. Some of the English stones of this formation have not the best of reputations, and architects will watch with interest the behaviour of the Cumberland stone used by Mr. Basil Champneys in the Rylands Library recently built in the very midst of Manchester.

Undoubtedly the best sandstones come from the *Carboniferous* group. Gloucester, Yorkshire, Lancashire, Durham, Northumberland, and Edinburgh, are counties well known for their carboniferous sandstones. The stone in this group varies greatly, from the coarsest millstone grit to the finest freestone and flagstone, but the freestone obtained from the well-known quarries near Bristol and in the West Riding of Yorkshire, and at Craigleith near Edinburgh, is close-grained, hard, and extremely durable; such stone is better able to withstand the smoky and acidulated air of towns than any limestone, and has the advantage of being more fire-resisting.

It is impossible in the space at my disposal to say more about the different kinds of building-stone, but one important point affecting the durability of stones and their suitability for the walls of houses must be mentioned. I mean their **capacity for absorbing water.** An absorbent stone is more likely to decay than one less absorbent, and will also render a house more damp and cold. In the Appendix a table will be found giving the total absorption and the *rate*

of absorption (a most important point) of various limestones and sandstones. It will be noticed that, speaking broadly, the limestones absorb a greater percentage of water than the sandstones, and also absorb it more quickly. The Weldon oolitic limestone *in one second* absorbs practically its full quantity of water.

A quick rate of absorption shows that every shower of rain must penetrate far into the stone, and so materially add to the dampness and coldness of the wall in which it is used. On the other hand, stones possessing a slow rate of absorption are scarcely affected by a passing shower, and only long-continued rain can render the walls built of them damp.

Stone Walls.—Building-stones, whether of sandstone, limestone, or granite, are named according to their shape and finish. The principal classes are three, namely, *rubble*, *squared rubble*, and *ashlar*, but each of these has several subdivisions.

Rubble may be *uncoursed*, or (for better work) uncoursed but with hammer-dressed joints, a variety of rubble generally known as *rustic* work; when flints are used they may be laid entire, or "polled", and laid with the fractured surfaces outward, the latter making the neater and better work.

The strength and imperviousness of rubble walls depend very much on the quality of the mortar used. If this is not good, the wall is bound to be more or less a failure. Much rubble is an inferior kind of stone, coarse, porous, and friable; on the other hand, flints and the rubble obtained from igneous and some other rocks, are exceedingly dense, non-absorbent, and practically proof against atmospheric attacks. With mortar of the best quality, used in sufficient quantity, walls built of good rubble are undoubtedly satisfactory and durable. Frequently rubble walls are finished externally with stucco, Douglas being a well-known example of a rubble-and-stucco town.

The angles of rubble walls, when these are not finished with stucco, ought to be formed with squared rubble, or ashlar, or good bricks.

Squared rubble gives a better and neater kind of wall than random rubble. Frequently, as in the case of the well-known Yorkshire wall-stones, the rock splits naturally along the planes of bedding into courses from 2 to 6 or even 8 inches thick, and the slabs are "nicked" to the required width (usually 6 inches) and roughly squared at the ends. The Yorkshire wall-stones are finished on the face chiefly in two ways, known as "straight-face" and "pitched-face", the latter (shown in No. 1, fig. 46) having a rough projecting face formed with hammer and pitching-tool or chisel. The pitched-face wall-stones are usually more expensive than the others, but they catch dirt and rain, and

are therefore more liable to be blackened by the soot and smoke of towns. Flat-bedded wall-stones of this kind, when laid in regular courses like bricks, are known as *regular coursed rubble.*

A variety of squared rubble is known as *irregular coursed*, or *snecked*, rubble; it consists in the use of stones of different depths, all laid with horizontal beds, but with large stones at irregular intervals, breaking the courses of the other wall-stones.

Ashlar wall-stones are of freestone requiring the use of hammer and chisel on beds, joints, and faces. It is unnecessary to describe minutely the different kinds of finish given to ashlar wall-stones; the beds and joints are usually boasted, while the finish of the faces may vary from the rough rock-face known as "pitched", to the finest "tooled" and the smoothest "rubbed".[1] The rougher the surface, the more opportunity does it afford for the lodgment of dirt and water, and the more likely is it to lead to the decay of the stone.

Ashlar should (except in certain exceptional positions) be laid on its natural bed, especially if the planes of bedding are easily discernible. Otherwise, the face of the stone will be likely to crumble or flake off. The ordinary mason is very fond of using one large stone (false jointed if required) instead of several smaller ones, thus saving labour in beds and joints; but in ninety-nine cases out of a hundred the large stone must be laid on edge with the natural bed of the stone vertical; whence comes decay.

The vertical joints of hand-worked ashlar wall-stones and of squared rubble are seldom squared back far enough. Frequently the appearance of two adjacent stones, seen from above, is as shown in No. 1, fig. 45; unless such joints are thoroughly flushed with good mortar (and how often is this the case?), driving rain is sure to saturate the wall: the wall will be a damp one and much time and money will be spent in attempts (more or less vain) to mend it. Certainly the joints should be squared back from the face not less than 3 inches.

The beds are often worked in the same way, a fault which may lead to the cracking of the stones (as shown in No. 2 at A) on account of the weight being concentrated on the edge, and also facilitate the ingress of water by forming an inclined plane A B, down which gravity conducts the water to the interior of the wall.

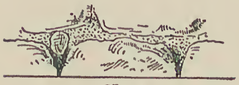
In the days before hollow walls were known, and railways and good roads had brought everything everywhere, our forefathers were sorely tried in their attempts to build **dry walls** of porous materials. Having learnt by bitter experience the folly of inward-sloping bed-joints like those in No. 2, fig. 45,

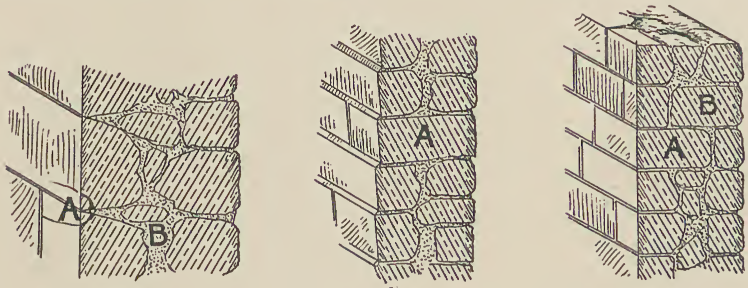
[1] Known also as "cleansed" or "polished".

the old builders went to the other extreme, and not content with level beds, often laid the stones as shown in No. 3. The projecting joint was always well pointed with mortar. The stone marked A is a through-stone. Many of the old stone buildings are damp to-day, while some have had their westerly faces covered with oil or other so-called "waterproof" solution, or with stucco or slates.

Ashlar wall-stones are, of course, a superior kind of stone used only for the face of the wall, the remainder of the wall being built of rubble or brick.

Stone walls are usually built with one "**through**" in every square yard, but as moisture is apt to fol-





No. 1. No. 2. No. 3. No. 4.

Fig. 45.—Stone Walls.

No. 1, Wall-stones with scamped joints. No. 2, Wall-stones with scamped beds. No. 3, Wall-stones laid with outward-sloping beds. No. 4, Stone wall with bond-stones A and B.

low the through, a better plan (where the thickness of the wall will allow) is to have two **bond-stones** in place of the through, as shown in No. 4 at A and B.

Stone-and-brick Walls.—Even in the heart of stone-districts bricks are now generally used for all internal walls, and for all but the facing of external walls. Their cheapness, and the facility with which they can be laid, have led to their adoption in lieu of rubble. Brick walls are also straighter than rubble walls, and require less plaster.

For cottages and small villas, external walls from 12 to 15 inches thick are often used; they consist of an outer skin of stone about 6 inches on the bed, and an inner lining of $4\frac{1}{2}$-inch brick, the space between being either left as a cavity or filled with mortar and scraps of stone and brick. This filling is almost invariably scamped, and, consequently, instead of rendering the wall more solid and impervious, actually facilitates the passage of damp by affording points of contact between the stone and brick. These walls have usually one stone through in every square yard, and two natched or rebated throughs (see No. 1, fig. 46) to each jamb of door and window. Sometimes, however, cast or wrought iron ties are used instead of through-stones, and are to be preferred in the case of hollow walls, as stone throughs form bridges, or rather aqueducts, conveying rain-water across the cavity to the brick and plaster within.

For larger buildings, and wherever the additional expense can be afforded, thicker walls should be used. These may be formed as shown in No. 2, where the heart of the wall is formed with rubble. This gives an opportunity for substituting bond-stones as at A for the through-stones previously mentioned, and the brick lining may be tied to the body of the wall either by inner bond-stones as B, or preferably by rows of headers every fourth or fifth course as at C C. The latter method is desirable where glazed bricks are used, and where the brick-work will not be covered with plaster. The mortar in walls of this kind should be of good quality—made from hydraulic lime or cement if possible,—and the walls will be improved by being run with grout.

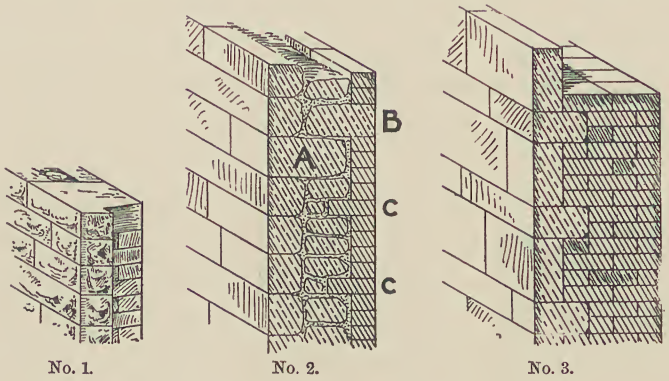


Fig. 46.—Stone-and-brick Walls.

No. 1, Window reveal with natched through-stone. No. 2, Wall with ashlar facing, brick lining, and rubble hearting. A, outer bond-stone; B, inner bond-stone; C C, brick heading-courses. No. 3, Brick wall with ashlar facing having alternate bond-courses.

Stone-and-brick walls of considerable thickness are often simply brick walls with a facing of stone, added for the sake of appearance or to preserve the bricks from atmospheric agencies. In such cases, the thickness of the ashlar courses may be some multiple of the thickness of the brick courses. An arrangement with alternate bonding-courses of stone is sometimes adopted, as shown in No. 3.

2. *BRICKS.*

The **bricks** of which we have hitherto been speaking have been used for internal work alone, and in almost every locality bricks sufficiently good for this purpose are made. The strength of common bricks of average quality is usually so much in excess of any weight which can be placed upon them in ordinary buildings, that no fear need be entertained of their collapse. And as the internal walls of houses are almost invariably covered with plaster or wainscot or other decoration, no objection can be raised against them on the score of appearance. True, living bacteria have been found in the pores of bricks, and inferior bricks will doubtless provide better accommodation for them than will denser bricks; but as common plaster is much more porous than common bricks, and a better

breeding-ground therefore for the organisms, the requirements of sanitary construction will be best satisfied by an improved quality of plaster. Of course, it is not meant that any kind of brick is good enough for internal work, but merely that many bricks may be used for internal work which would be condemned for external work on account of their appearance and inability to withstand for any length of time the attacks of wind, acidulated rain, and frost.

Bricks for external facings, however, require careful selection. There can be no doubt about the durability of good brickwork. On the other hand, there can be no doubt that by far the greater part of the brickwork which has been erected in our towns within the last fifty or a hundred years, already shows unmistakable signs of decay. The railway traveller, as he enters London or any of the large manufacturing towns, has merely to look out of the carriage-window, to be satisfied of the truth of this statement. Wind and rain and frost, and the acids present in the air and rain of these towns, are slowly but surely eating away the arrises and faces of the bricks.

It is strange that no scientific system of tests for bricks has yet been formulated. In the case of Portland cement, engineers, after much disputation and some errors, have laid down certain tests by which the strength and durability can be ascertained, but architects and engineers still judge bricks by rule of thumb and more or less bitter experience. Occasionally the weights required to crack and crush certain bricks are obtained by experiment, but beyond this little has been done.

Here are the characteristics of a good brick, according to the recent utterance of a well-known architect:—

"1. Regularity of shape, so that when built into a wall the pressure is equal over its surface.

"2. Toughness as opposed to brittleness,—*i.e.* it ought not to snap when broken [*sic*], but should require two or three hard blows.

"3. Clearness of ring when gently knocked against another brick, and not a dull, heavy thud.

"4. Homogeneity of surface and texture in the interior, and, above all, absence of small stones and pebbles or lumps of chalk.

"5. Non-porosity,—*i.e.* a slowness in absorbing water."

These five points are undoubtedly well worthy of attention,—far be it from me to detract from them in any way,—but they are not sufficiently definite. For instance, what is meant by a "hard blow"? and what by "slowness" in absorbing water?

Clearly a more definite and less empirical system of judging bricks is desirable, and two tests especially should be carefully defined, namely:—

1. The *total* absorption of water, coupled with the *rate* of absorption.

2. The resistance of the brick to acids (and perhaps abrasion), so that the durability of the brick in town-air and rain may be inferred.

The former test would present no practical difficulties whatever, and the latter would apparently be no more difficult than (say) the hot-water method of testing the soundness of Portland cement.

Two of the most important facts to be ascertained about a brick,—especially a facing-brick,—are undoubtedly the amount of water which it will absorb, and the rate of such **absorption.** The former is important, partly because it affords some indication of the proneness of the brick to produce damp walls, and partly because it shows to some extent the degree to which the brick may be acted upon by rain, frost, &c. The rate of absorption is, however, a surer index of the ultimate dampness of the wall, as a rapid rate means that a wall will become damp with every shower, while a slow rate shows that only long-continued rain will seriously affect it.

Table I. gives the weight of certain bricks, together with their absorption and rate of absorption. It is reprinted from *The Builder* for May 25, 1895, with the addition, however, of a column containing the weights per cubic foot of the several bricks. The results show that, as a general rule, the heavier the brick, the less is the amount of water absorbed. This holds true in almost every case, and it is quite possible that, had the measurements of the bricks been given more exactly, the relation between the weight and absorption would have been even more striking. It appears also that some of the bricks had not absorbed their full quantity of water,—Nos. 1, 3, 4, for instance,—and that if the tests had been continued another week, the ratio between weight and absorption would have held true of these bricks also. Indeed, for bricks whose actual substance has the same specific gravity, the total absorption will vary inversely as the weight, except, of course, in the case of bricks coated with an impervious glaze.

Nothing but an actual test can give the **rate of absorption,** as this depends largely on the nature of the outer skin of the brick. If this be very smooth and vitrified, and free from cracks, the water cannot find easy entrance, nor can the air within the brick escape without difficulty; hence such a brick will have a slow rate of absorption. On the other hand, coarse, soft, underburnt, and fissured bricks may in a few minutes take up nearly all the water they can possibly absorb; notice that in 30 minutes the bricks numbered 7 to 18 absorbed on the average 85 per cent of the total amount. Comparisons may be odious, but they are certainly often useful, and one cannot help remarking upon the superior resistance to damp displayed by bricks 1 to 4.

TABLE I.

WEIGHT, ABSORPTION, AND HARDNESS OF VARIOUS BRICKS.

No.	Description of Brick.	Locality Where Made.	Dimensions.	Dry Weight.		Absorption of Water per Cent of Dry Weight in					Degree of Hardness.
				1 Brick.	Per Cub. Ft.	1 Sec.	1 Min.	30 Min.	1 Day.	1 Wk.	
			Inches.	Lbs. Ozs.	Lbs.						
1	Wire-cut Metalline,......................	Buckley, near Chester,......	8·9 × 4·2 × 2·5	8 0½	148·5	—	·38	·38	·77	1·16	9
2	Pressed „	„ „ „	8·6 × 4·1 × 2·4	7 7	151·8	·42	·42	·84	1·26	1·26	9
3	Vitrified Plain Paving,................	Heathfield, Newton Abbot,	9·1 × 4·4 × 2·0	6 12	143·8	—	—	—	1·38	1·85	8·5
4	Blue Facing,............................	Ruabon, N. Wales,..........	8·8 × 4·2 × 2·9	8 9½	136	·36	·36	·36	1·46	2·54	8·5
5	Red „	„ „	8·8 × 4·2 × 3·0	8 13½	137·8	·35	1·06	2·12	5·31	5·31	8
6	Best White Glazed, ...	Heathfield, Newton Abbot,	8·8 × 4·3 × 2·8	7 9½	123·8	·41	·82	2·88	5·76	6·17	8·5
7	Brook Hill Blue,........................	Buckley, near Chester,......	9·1 × 4·3 × 2·5	7 4	128	1·72	5·17	6·03	6·90	8·18	7·5
8	Flintshire White,.......................	„ „ „	9·0 × 4·3 × 2·6	7 4	124·5	2·15	6·46	8·62	10·34	10·34	7
9	Red hand-made Facing (No. 12),...	Bracknell, Berks,............	8·9 × 4·1 × 2·5	6 4½	118·9	·49	2·94	10·94	12·93	12·93	3
10	Machine-made wire-cut Red Facing (No. 13*x*),............................	„ „	9·0 × 4·3 × 2·6	6 9½	113·6	·47	1·89	9·47	13·74	13·74	3
11	Hand-made pressed Red Facing (No. 4),..................................	„ „	8·8 × 4·3 × 2·5	5 15½	109	2·09	7·84	13·61	14·13	14·13	2
12	Red, ...	Dunton Green, near Sevenoaks, ...	9·1 × 4·3 × 2·5	6 4	110·4	1·00	4·00	13·50	15·00	15·00	3·5
13	Red Rubber (No. 9), ...	Bracknell, Berks,............	9·8 × 4·9 × 3·1	9 3	106·6	2·04	6·80	13·94	15·30	15·30	1·5
14	White Gault,.............................	Dunton Green, near Sevenoaks, ...	9·0 × 4·3 × 2·5	6 4	111·6	1·50	6·50	18·00	20·00	20·50	7

A description of the raw materials, and of the **processes of brick-making**, would be out of place here, but it is necessary to point out that bricks may be hand-made or machine-made, the latter being now most common. Machine-made bricks are of two kinds, wire-cut and pressed. In making the former, the clay is forced through a die a little larger than the bed-measurements of the finished bricks,—that is to say, about 9 inches by $4\frac{1}{2}$ inches,—and after leaving the die, is cut into slices about 3 inches thick; wire-cut bricks are therefore without indentations or "frogs". Pressed bricks are each submitted to pressure in a machine before being burnt, and have usually frogs on one or both beds, and often also the name or initials of the maker impressed on them. Pressed bricks, as a rule, are more dense and impervious, and have smoother faces and truer arrises; they are therefore almost invariably used for good external work. The frogs afford a key for the mortar, but are the cause of kiln-cracks in the bricks, and lessen their ultimate strength.

Facing-bricks may be obtained of various **colours**,—white, buff, numerous shades of red, and blue-black,—the colour alone being no guide to the real quality of the brick.

Cutters or rubbers are somewhat soft and absorbent bricks, of a yellow or red colour, prepared from materials of an extreme degree of fineness, and used for panels, arches, splays, and other positions, where the bricks must be carved, or cut and rubbed to shape. They are now being largely superseded by bricks which have been moulded to the desired shape before being burnt, and by terra-cotta, as these are as a rule much more durable, and at the same time—if a considerable number of pieces of one pattern are required—cheaper.

Of ordinary facing-bricks there are so many varieties, and these so constantly changing, that only a cursory glance can be attempted.

Good **white bricks** are made from the gault clay in Kent and Bedford, while some of the best are burnt from the china-clay deposited in pockets among the Devonshire hills. They may also be obtained from several other counties.

The **red bricks** made at Ruabon in Denbighshire are among the best in the country. The Leicestershire and Hampshire pressed bricks also enjoy a good reputation. In all these counties moulded bricks for plinths, sills, string-courses, jambs, and many other purposes are made. Other red pressed facing-bricks of good quality are manufactured at Peterborough, and in Berkshire, Staffordshire, Lancashire, Yorkshire, and other counties.

Staffordshire is the centre of the **blue-brick** industry, the best bricks being produced in the southern part of the county. The peculiar colour is due to the large quantity of iron in the clay. The bricks are not all blue to the core;

usually the middle of the brick is red, shading gradually into the blue, but, whatever the colour, the material should be vitrified throughout. The best Staffordshire bricks are known as "best pressed"; wire-cut bricks are often called "seconds", and are cheaper, and not so dense and true.

Much inferior stuff is now sold as Staffordshire ware,—stuff made of coarse gritty materials, artificially coloured, and warped and cracked in every direction. Quite recently I had to condemn a number of such bricks which had been brought to a building for heavy foundation work; some of the bricks were so badly cracked that one could see right through them.

Good Staffordshire blue bricks are extremely hard, heavy, impervious, and durable, suitable for all situations where great weights have to be carried and damp to be resisted; hence their value for foundations and basement-walls, and for engineering works. Their colour renders them objectionable for the facing of houses above the level of the plinth or base-course.

The best bricks for external facings in towns are undoubtedly "best" **salt-glazed bricks,** those made in the neighbourhood of Leeds and Halifax being of excellent quality.

Salt-glazed bricks are of two kinds, namely, *common salt-glazed* (known also as "seconds"), which are merely ordinary pressed bricks fused on the surface by common salt being thrown into the kiln, and *best salt-glazed*, the faces of which are dipped into a "slip" of the finest sifted clay before being fired and salted. Bricks of the former kind are chiefly used for sewers, manholes, and other places, where a clean impervious surface is required at a comparatively little cost. The "best" bricks, however, are used for external facings, and for internal walls, dadoes, urinals, &c. They are hard, durable, true in shape, and free from surface-cracks, and, being vitrified on the face, they are clean, easily washed, and practically non-absorbent. As the "slip" is of the same clay as the brick itself, the whole is fused into one mass in the kiln, and the glaze cannot shell off as it sometimes does from "enamelled" bricks.

An artistic advantage in favour of salt-glazed bricks consists in their rich and varying colour, which imparts a character and movement to a wall very different from the dull monotony of ordinary (or indeed of enamelled) brickwork. An exceedingly picturesque example of their use—by what architect I do not know—may be seen in Great George Street, London. They have also been used in the plinth of the Finsbury town-hall. There can be no doubt that they will be more frequently adopted in years to come.

Enamelled bricks are good pressed bricks which, after being fired once, are dipped several times into "slips" and then into a glaze before being burnt a

second time. In the "wet-dip" process the preliminary firing is omitted. They are really bricks to the face of which a porcelain plate (or, in inferior bricks, an earthenware plate) is fused. They are not greatly to be commended for external use as the glaze may fly under stress of weather, but of their advantages for internal work there can be no question. In water-closets, urinals, lavatories, bath-rooms, sculleries, corridors, basements, areas, and other places where dirt and darkness are wont to abide, enamelled bricks may be used with vast improvement of "sweetness and light". They may also be adopted in larders, pantries, and kitchens, and even in dust-bins and the inspection-chambers of drains. The "best" bricks of the best makers are now of such excellent quality that little fear of "shelling" or decay need be entertained.

Bricks with cracked or discoloured faces, or chipped edges, are sold as "seconds" or "thirds", the perfect bricks being known as "best".

Enamelled bricks of several colours can now be obtained,—chalk white, ivory white, cream, buff, pink, and various shades of red, brown, blue, and green. Black bricks are also made, and "soft-glaze" bricks of the nature of majolica. The latter are frequently crazed on the surface, and are not considered as durable as hard-glaze bricks. Enamelled moulded bricks are also made, and also bricks with patterns printed in one or more colours.

Faience is a name which has been applied to a kind of glazed brick and tile. The material has been largely adopted for internal decoration, and in some instances the external surfaces of buildings have been formed of it, notably the new "Tube" stations in London. Almost any colour can be produced.

The shape of bricks is a matter of considerable importance. The thickness is not a matter of much moment. Roman bricks were usually more like tiles than modern bricks, being little more than an inch thick, and I have in Spain seen new bricks only $1\frac{3}{4}$ inches thick; in this country, however, the thickness is usually somewhere between $2\frac{3}{4}$ and $3\frac{1}{8}$ inches, although many architects are now in favour of thinner bricks on the score of appearance. The length and breadth are of more consequence than the thickness; in order to obtain proper bond without undue cutting, it is essential that the length of the brick be twice the breadth *plus* the thickness of one mortar-joint, that is to say, if the breadth be $4\frac{1}{4}$ inches, the length should be $8\frac{3}{4}$ or $8\frac{7}{8}$. The reason for this will be apparent on considering the question of bond. Various more or less intricate shapes of brick have at different times been devised, but the common oblong is still almost invariably adopted, except for purposes of ornament.

Brick Walls.—The art of **bricklaying** now demands notice. To ensure a strong wall, the bricks must be so laid that those in one course break joint with

those in the course below; in other words, the bricks must be thoroughly bonded together. The bond must tie the wall together both longitudinally and transversely. There are several **varieties of bond,** of which the principal are:—

1. *English bond* (No. 1, fig. 47), consisting of alternate courses of headers A A and stretchers B B; this is the strongest form of bond, and does not provoke scamping.

2. *Garden-wall bond* or *Scotch bond*, consisting of one course of headers to every three, four, or five courses of stretchers; this is a modification of English bond, used chiefly for internal walls.

3. *English cross bond* (No. 2), another modification of English bond, effected by moving each alternate course of stretchers a half-brick on one side

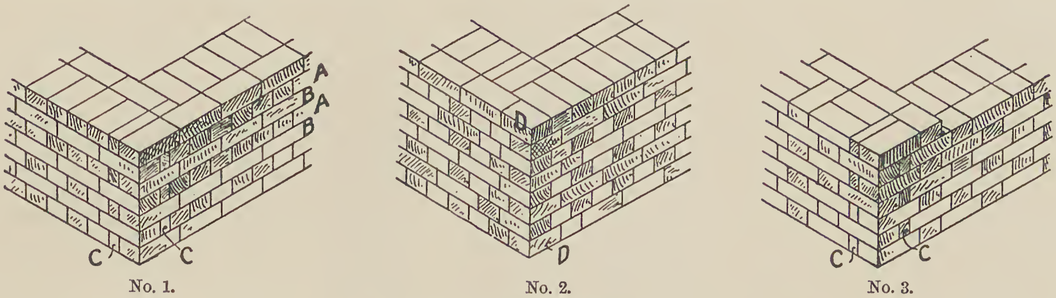


Fig. 47.—Bond in Brickwork.
No. 1, English bond. No. 2, English cross bond. No. 3, Single Flemish bond.

of the other courses of stretchers, so that the joints in the alternate courses are plumb over the centres of the bricks in the other stretching courses; this has rather a pretty effect, and is not uncommon in Holland and Belgium; the Chateau at Spontin, and the Chateau Freyr near Dinant, are excellent examples.

4. *Single Flemish bond* (No. 3), consisting of header and stretcher alternately in each course on one side of the wall, and of alternate courses of headers and stretchers on the other side; this bond necessitates a considerable number of half-bricks or false headers, and is deficient in strength.

5. *Double Flemish bond*, consisting of header and stretcher alternately in each course on *both* sides of the wall; this also is a weak kind of bond, being deficient in headers, and necessitating a great proportion of half-bricks.

6. *Stretcher bond* or *chimney bond*, consisting wholly of stretchers, and applicable only to half-brick walls, such as partitions and chimneys.

7. *Header bond*, consisting wholly of headers, and applicable only to 9-inch and thicker walls; it is weak, but is useful for walls of quick curvature, where the expense of specially-shaped bricks must be avoided.

A glance at the illustrations will show that, in order to make the bricks

break joint with each other, it is necessary to insert near the angles narrow pieces one-fourth the length of the ordinary brick, as shown at C C; these are known as closers, and should always be placed next to the angle brick. Instead of the quarter-brick closer a three-quarter brick is sometimes placed at the angle of the wall, as shown at D D in No. 2, fig. 47.

Sometimes facing-bricks thinner than the bricks used in the remainder of the wall are for æsthetic reasons preferred. It is in such cases impossible to make a really good bond between the two kinds of brick, as headers can only be inserted when the facing and backing have risen to the same level. In fig. 48 this occurs only once in every six courses of face-bricks. If, as will probably be the case, Flemish bond has been adopted, then only alternate bricks in every sixth course will be headers. Thin facing-bricks may, however, be used without detriment for the facing of hollow walls, and also of walls in which a small cavity is formed and filled with asphalt or other composition.

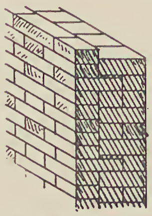


Fig. 48.—Thin Facing-bricks with Common Brick Backing.

For the formation of angles other than right angles, **purpose-made bricks** should be obtained of the desired shape; except of course for rough work, when ordinary bricks roughly cut to the required angle may be used. Bricks with one angle rounded, and known as bull-nosed bricks, are largely used for the salient angles of internal walls where plaster is not adopted; they are especially to be desired in glazed brickwork, as the sharp angle of a square brick is easily chipped by a blow. The shaping of the brick, however, need not be confined to a simple curve; splays, and moulds of various kinds, may be used. In hospitals the re-entrant angles of the rooms are now generally formed curved instead of square, special bricks being used for the purpose; the curve facilitates dusting and washing, and may with advantage be adopted in sculleries, water-closets, and other domestic offices.

Sill-bricks should be jointed with **Portland-cement mortar**; so also should plinths, string-courses, copings, and other projecting members, and the brickwork of parapets and chimney-stacks.

Glazed bricks are often laid in **bricklayers' putty,** which is a mixture of fine white sand or marble dust, and pure lime which has been slaked in a large quantity of water, strained, and allowed to stand till it has become of the consistency of thick cream. Nowadays Portland cement is often used mixed with fine sand, and makes better work. The joints in glazed brickwork, especially in hospitals, are sometimes painted with enamel paint to render them impervious.

As the joints in glazed brickwork are always thinner than those in the brick

backing, the glazed bricks should be about one-eighth of an inch thicker than the common bricks, in order that the courses may be kept level and proper bond obtained.

3. *TERRA-COTTA.*

Terra-cotta is a superior kind of brickwork, but possessing in the main the same general characteristics. It is burnt from carefully selected and prepared clay, and may be had of several colours and shades—white, buff, brown, pink, red, and blue—the red being most generally preferred. The face of the blocks is carefully smoothed with a table-knife or other instrument before the clay is thoroughly dry. This gives a close finish to the surface.

On account of the development of cracks and twists in solid blocks during the processes of drying and burning, terra-cotta blocks, unless of small dimensions, are made hollow, the clay being either forced through a die, forming blocks of a square-channel shape, or filled to a thickness of 1½ or 2 inches into moulds of the desired shape, with clay struts where required to give rigidity to the blocks. After delivery at the building-site, the blocks are **"loaded" with concrete,** which is sometimes composed of only one part of Portland cement to ten parts of coke breeze; this is a very weak concrete, too weak where much weight has to be borne, but in stronger concretes great care must be taken that the cement has been properly air-slaked by being exposed for two or three weeks in a dry building, and occasionally turned, as otherwise the slight expansion of the cement may injure the block.

Of the details of manufacture nothing need be said, but a few hints on the **design and use** of the material may prove of service. The design should not necessitate the use of large blocks; the smaller the blocks the less is the amount of warping in each, and, consequently, the less is the difficulty in fixing the blocks to make neat work. Terra-cotta should always be subjected to compressive stress, not to transverse; for example, it ought not to be used in the form of lintels, but of arches, flat or otherwise. In moulded work, the profiles of the moulds should be such as will allow the walls of the block to be of uniform thickness throughout, otherwise warping and cracks may be developed in drying and burning. "Undercut" moulds especially should be avoided.

Frequently, where **inferior clay** is used, the dried blocks, immediately before being placed in the kiln, are dipped in a thin fine clay, in order that the finished blocks may have a smooth surface and uniform colour. Under certain little-understood conditions of clay and burning, such surface coats are apt to peel

off. If dipping has been practised, it can usually be detected by striking the face of the block with a sharp chisel, when some of the thin coat will probably fly off, or at least be revealed, or, better, by gently tapping the end or bed of the block with some hard substance close to the face which has been dipped.

Sometimes a **scum** is formed on the face of terra-cotta during the process of drying. As this would detract from the appearance of the finished work, it is usually removed with brush and water before the terra-cotta is placed in the kiln, but as the formation of scum on the face can be prevented by preventing evaporation taking place through that face, such a damaging process as brushing ought not now to be adopted.

The **durability** of good terra-cotta is beyond question, but, as in all other materials, the quality is by no means uniform, and much terra-cotta is far from satisfactory. Ruabon terra-cotta has been found to absorb water weighing ·51 per cent of its dry weight in 1 second, the same quantity in 1 minute, 1·80 per cent in 30 minutes, and 5·67 per cent in 1 day. No increase took place with a week's immersion. This shows that Ruabon bricks and terra-cotta are of equal quality as regards absorption, and much better than many facing-bricks. See Table I., page 105.

4. *CONCRETE.*

For massive engineering works, such as breakwaters, docks, and sea-walls, and for the foundations of structures great or small, **concrete** has been largely used, but for the walls of ordinary houses it **has not found much favour.** "Several causes have combined to hinder architects from adopting it. Notably among these are the dangers arising from its manufacture by careless workmen and unscrupulous contractors, the difficulty and expense of moulding it to curved and irregular forms, and the bald appearance and unlovely colour of the material itself.

"Other objections to concrete walls are their homogeneity and hardness, which render the hanging of pictures and the fixing of plugs difficult tasks, and which make alterations a costly affair (this last is raised as an objection sometimes, but may perhaps be regarded as an advantage). The ease with which sound is transmitted through concrete walls is certainly a point against them. But it may be said, on the contrary, that good concrete is considerably less pervious than brickwork and some kinds of stone, stronger and more durable, and, under certain circumstances, cheaper."[1]

[1] *Concrete: Its Nature and Uses*, by George L. Sutcliffe, A.R.I.B.A.

Materials.—For the matrix of concrete for external walls Portland cement is by far the most satisfactory material. The best cement only must be used—finely ground, strong, and sound.[1] The sand must be sharp, free from saline, clayey, and organic matter, and not too fine; and the aggregate must be hard, impervious, angular, clean, and not too uniform in size. As the absorption and perviousness of concrete depend largely on the nature of the aggregate, soft bricks and coarse-grained porous stone must not be used. If good results are required, not only must the cement be of the best, but also the sand and broken stone, and the materials must be separately measured, and thoroughly mixed together with a proper quantity of clean water. Constant intelligent supervision is also necessary.

The concrete should contain sufficient cement to fill the interstices in the sand, and the combined cement and sand (*i.e.* the mortar) should thoroughly fill the voids in the aggregate. To attain this object, the ingredients should be used in the following proportions—1 part of cement + $1\frac{1}{2}$ parts of sand + 3 or 4 parts of suitable aggregate. Poorer concrete than this is often used in walls, but it is not wise to do so, at any rate in exposed situations, unless the concrete is faced with brick or stucco, or some other material. Concrete used in the construction of walls in London is specified by the County Council to be composed of "*Portland cement and of clean Thames or pit ballast, or gravel, or broken brick or stone, or furnace clinkers, with clean sand, in the following proportions, viz. one part of Portland cement, two parts of clean sand, and three parts of the coarse material, which is to be broken up sufficiently small to pass through a two-inch ring*".

Although good concrete is undoubtedly stronger than an ordinary brick wall of the same thickness, the London County Council requires "**the thicknesses of concrete walls** *to be equal at the least to the thicknesses for walls to be constructed of brickwork*". A further regulation is that "*such portions of concrete party-walls and chimney-stacks as are carried above the roofs of buildings* [must] *be rendered externally with Portland cement*".

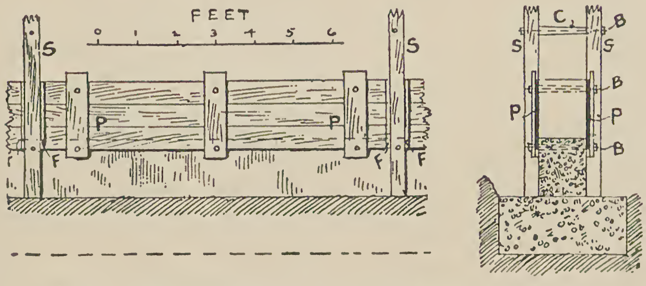


Fig. 49.—Elevation and Section of Building-frame for Concrete Walls.

Fig. 49, which is reproduced from the writer's work on Concrete, gives an

[1] See pages 83 and 84.

elevation and section of a simple **building-frame for concrete walls;** S S are the standards bolted together in pairs at distances of from 6 to 12 feet, P P are the "shutters" or movable panels of wood, also bolted together in pairs by means of the bolts BB, which pass through wood cores or distance pieces C, these being tapered slightly in order to facilitate removal when the concrete has set; the shutters are kept in position by wood fillets, F F, nailed to the standards. Many different kinds of building-frames have been patented, but the simple arrangement illustrated will suffice for ordinary purposes.

Inferior concrete must be faced outside with **Portland-cement stucco,** which may be "divided into ashlar" by sunk lines (a bad plan, as the sinkings retain moisture, and lead sometimes to the flaking of the surface-coat), or may be finished in colour with oil paint or duresco, or covered with "rough-cast".

Concrete blocks are now used to a considerable extent, not only for sea-walls and other engineering works, but also in buildings. For the latter purpose, however, the blocks are often known as "artificial stone", and are used chiefly in the form of "dressings", such as door and window heads, window-sills, moulded string-courses and cornices, panels, finials, and other ornamental work; they are made in various colours, but chiefly red and buff. When properly made of good materials, concrete blocks are sound and durable, but their appearance is not as a rule very pleasing. They are laid like ordinary masonry.

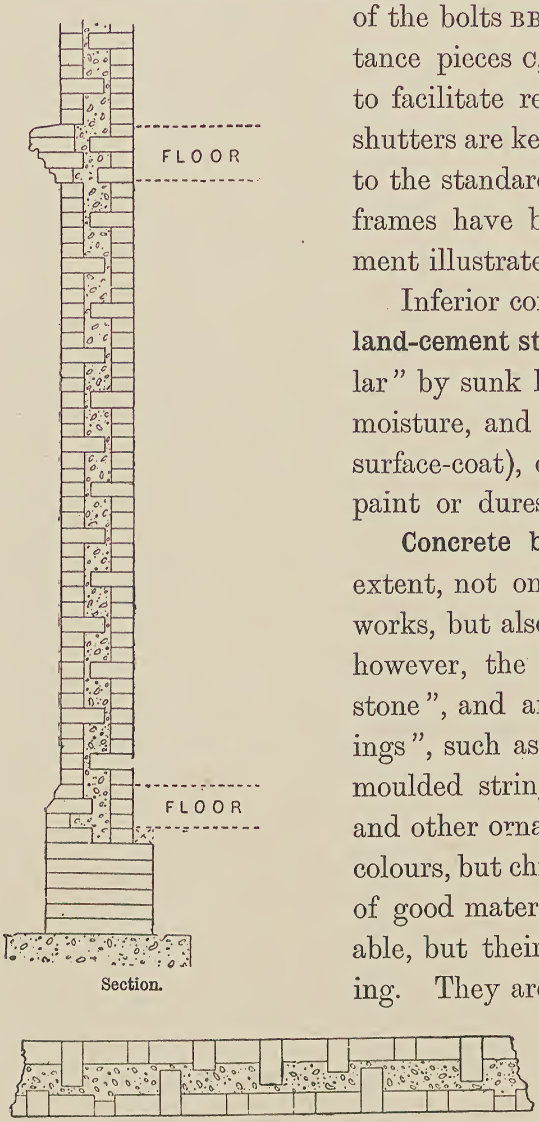
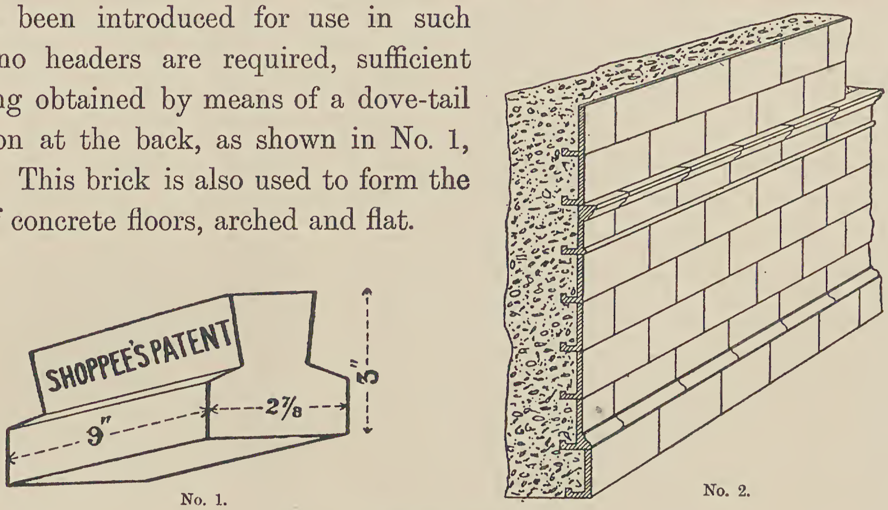


Fig. 50.—Brick and Concrete Wall.

Brick or Stone Walls with Concrete Hearting.—One great objection to the construction of solid concrete walls is the cost and inconvenience entailed by the use of the temporary scaffolding and shutters, and the objection has special force in the case of buildings of irregular shape. **Combined brick-and-concrete walls** have therefore been sometimes adopted, as shown in fig. 50, the half-brick skins taking the place of the temporary shutters. Mr. John Gethin, A.R.I.B.A., has used walls of this kind, 15 inches thick, in exposed situations in Wales, and has found

them to be not only very strong but also perfectly water-tight. The concrete was composed of one part of Portland cement and five parts of aggregate; the bricks were laid in Flemish bond, all the headers being "snap" headers, except those shown in the illustrations. This method of construction can be adopted for thicker walls with greater economy, and, of course, is applicable to stone-faced walls as well as to brick.

A special kind of glazed brick, known as **Shoppee's patent brick,** has recently been introduced for use in such walls; no headers are required, sufficient key being obtained by means of a dove-tail projection at the back, as shown in No. 1, fig. 51. This brick is also used to form the soffits of concrete floors, arched and flat.



No. 1. No. 2.

Fig. 51.—Facings for Concrete Walls.

No. 1, Shoppee's Patent Brick. No. 2, Cockrill-Doulton Patent Tiles.

The **Cockrill-Doulton Patent Tiles** fulfil the same purpose. They are L-shaped tiles, measuring 9 inches by 6 inches on the face, and $2\frac{1}{2}$ inches on the base or bed. A course of tiles is laid on each face of the wall, and the intermediate space filled with soft concrete, care being taken not to disturb the tiles during the operation; and so course by course. As the tiles are glazed, and therefore practically impervious and non-absorbent, walls properly constructed in this manner are likely to be dry and durable, besides being clean and of pleasing appearance. The tiles are made in brown salt-glazed stoneware, cream enamelled stoneware, and with glazes of various colours; and moulded tiles are also made as shown in No. 2, fig. 51. Quarter-circle tiles are made for the internal angles of walls and for the angles between walls and floors, but in the latter situation—if the floor be of wood—the angle-hollow should be of wood, scribed to fit the tiles above and properly jointed to the wood flooring. The tiles are now made with a dovetail projection along the back, about 2 inches from the upper edge, to give better adhesion for the concrete.

5. *HOLLOW WALLS.*

In exposed situations rain is often driven by the wind quite through a solid wall, especially when the materials of the wall are porous or badly laid. Sometimes the dampness of walls is due to neglect in flushing the joints with mortar, or in the external pointing, but in many cases the moisture is actually driven through the bricks or stones. In stone walls the moisture usually follows the "throughs", and not infrequently these can be counted inside a room by the damp patches on the plaster.[1] Something will be said in a subsequent section on the means to be adopted in order to improve existing damp walls, but for the present we are concerned with prevention, which is easier than cure.

Of course a solid wall can be made impervious by means of a vertical asphalt layer between two skins of brick or stone, as described on page 90, and in other ways, as explained in connection with basement walls, but, as a rule, quite as effective protection from damp can be obtained at less cost by forming a simple cavity in the wall. Solid walls, however, have certain advantages; they do not harbour vermin, and for the same quantity of materials they are stronger and cheaper.

Theoretically, a **cavity** half an inch wide is to all intents and purposes as effective as one a foot wide, but a narrow cavity is so easily bridged by a piece of brick or a chance dropping of mortar, that a width of not less than 2 inches should be allowed; frequently cavities 2½ or 3 inches wide are adopted.

The **thickness of hollow walls** for small villas is often only 11 inches, that is to say, two half-brick skins and a 2-inch cavity, and where cheapness is a primary consideration this is all that can be afforded. At the same time it must be said that a thicker skin on at least one side of the cavity is preferable, and in London and some other places is indeed obligatory. Thus, the London by-law on hollow walls ordains that "*when hollow walls are constructed, there shall be a wall on one side of the hollow space of the full thickness prescribed" for solid walls*; in other words, the total thickness of a hollow wall must exceed that of a solid wall for a similar building by the width of the cavity and the thin skin on one side of it. Consequently in London hollow walls are not often used. In many urban and rural districts, however, the total thickness of the wall-material in hollow walls (*i.e.* exclusive of the cavity) need not exceed the thickness specified for solid walls.

[1] Damp stone-shaped patches, however, are not always due to this cause; they may be the result of condensation, the shape of the cold and dense stones being marked on the plaster by patches of damp, while the warmer and more porous mortar-joints leave the plaster apparently dry.

Where a wall 11 inches thick is not sufficient, additional strength is usually gained by increasing the thickness of the skin on *one* side only of the cavity, and the question is often asked, Should the thicker skin form the external face of the wall or the internal? The balance of opinion is in favour of the latter alternative, as in this way the greater part of the whole wall is kept dry, and the floors and roof are more firmly supported; "set-offs" (for reducing the thickness of the wall) can also be more easily arranged without breaking the continuity of the cavity, as shown at A in No. 1, fig. 52.

Several forms of **tubular bricks and concrete blocks** have been devised for the purpose of forming hollow walls, but none has met with general acceptance. Ordinary bricks are so cheap and convenient that there is little possibility of any patented hollow wall being largely adopted.

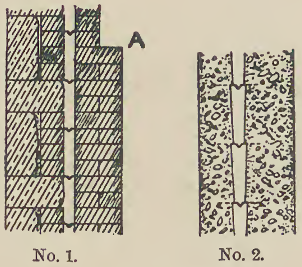


Fig. 52.—Hollow Walls.
No. 1, Stone and brick. No. 2, Concrete.

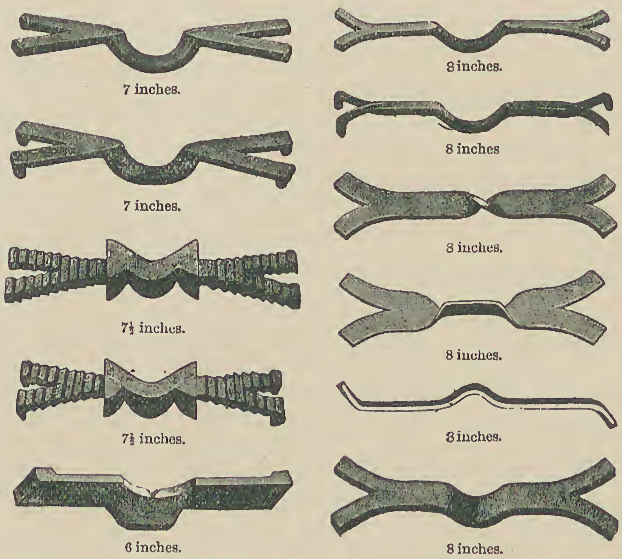
In the case of **stone-and-brick walls,** cavities may be formed exactly as in brick walls, an outer skin of stone being substituted for the outer skin of brick, but as ordinary wall-stones vary much on the bed, a somewhat wider cavity ought to be specified. In thicker walls, however, it is customary to build the outer skin of the wall with a lining of brick, the stone and brick being tied together with bond-stones; the inner skin is entirely of brick. A reference to No. 1, fig. 52 will explain this method of construction.

In **building hollow walls** great care must be exercised that the cavity is continuous throughout the circuit and height of the building. In order to prevent the cavity being bridged with droppings of mortar or brick-bats, battens or iron pipes wrapped with haybands, or haybands alone, should be placed in it, and lifted out when the wall is ready to receive the iron ties or bonding-blocks; the battens or pipes are then laid on the top of these, and the wall carried to the necessary height for the next row of ties, and so on.

Cavities can be formed in concrete walls, as shown in No. 2, fig. 52, by inserting in the required position between the temporary shutters a 2-inch or 3-inch plank, tapering slightly in thickness from the top edge to the bottom; the taper facilitates the removal of the plank. When the concrete has hardened sufficiently the plank is withdrawn, and metal ties are then laid across the cavity; on these ties the plank rests during the formation of the next layer.

In order to bind the two skins of a hollow wall together and so strengthen the structure, metal **wall-ties, or bonding-blocks** of brick or stoneware, are inserted. Sometimes dense bricks of ordinary shape are used, but as moisture is apt

to pass along (if not through) these, it is better to adopt special blocks or ties. Iron ties are from 6 to 9 inches long, and may be either cast, as in No. 1, fig. 53, or wrought, as in No. 2. They should be of such a shape as to prevent water passing over them to the inner portion of the wall. When the bricks are without "frogs", the projections under the ends of the ties must be omitted. The cast-iron ties are sometimes rendered malleable in order to prevent them snapping. All metal ties should be galvanized, or dipped in boiling tar and sanded, before being used; otherwise they may rust and injure or stain the wall. Bonding-bricks are usually of semi-vitrified ware. Two good examples are given in fig. 54. That marked A is so shaped that water cannot pass along it or mortar rest on it. The size is $9\frac{1}{4}$ inches by $4\frac{1}{2}$ inches by 3 inches. The bonding-brick B is made by J. C. Edwards, and may be had with $2\frac{1}{4}$ or $4\frac{1}{2}$ inches bearing on the walls, and for cavities 3 or $4\frac{1}{2}$ inches wide. The upward slope prevents moisture passing from the outer to the inner skin of brickwork. Blocks of other shapes can be obtained from other makers. For the sake of appearance the bonding-brick is seldom allowed to show on the face of the wall, as it would not match the colour of the ordinary brickwork; where the outer skin is only a half-brick in thickness, the bond extends into it only $2\frac{1}{4}$ inches, certainly not an amount calculated to give excessive stability. Any shortcoming in this respect, however, can be counterbalanced by the **spacing of the bonds.** These, whether of iron or stoneware, are usually placed 27 inches apart horizontally, and 9, 12, or 18 inches apart vertically; that is to say, from seven to three are allowed in each square yard of the wall.



No. 1, Cast-iron. No. 2, Wrought-iron.
Fig. 53.—Wall-ties.

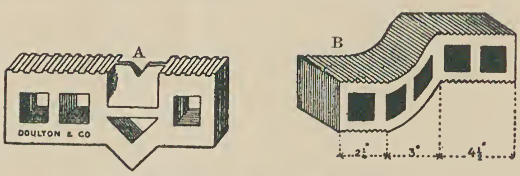


Fig. 54.—Bonding-bricks for Hollow Walls.

Plate III. gives plans, sections, and elevation of 11-inch and $15\frac{1}{2}$-inch hollow brick walls with stone dressings.

HOLLOW BRICK WALLS WITH STONE DRESSINGS.

BB. Stoneware bonding-blocks across cavity.
CC. Stoneware ventilating damp-course.
DD. Asphalt damp-course under parapets and gutters.
E. Asphalt on concrete ground-layer.
F. Weathered and throated stone sill.
G. Weathered and throated stone coping.
H. Lead gutter.
I. Lead flat over bay-window.
K. Roof-tiles on horizontal and vertical laths, laid on boards covered with felt.
L. Ordinary laths and plaster.
M. Plaster on expanded metal lathing secured to small steel angles fixed to wood joists.
N. Parquet flooring laid on inch tongued and grooved boards.
O. Wrought-iron casements.
P. Rain-water pipe.
Q. Through-stone course closing top of cavity.
RR. Air-bricks ventilating the floor.

The cushion of air in the middle of a hollow wall helps to keep the **temperature of the house** more equable; but this advantage is lost when the cavity is over-ventilated, a condition which may be caused by porous materials, bad mortar-joints, or by excess of air-grates. Holes for egress of moisture are often provided at the foot of the cavity, but a better plan is to lay the damp-course in the brickwork on each side of the cavity and to continue the cavity below it, so that the moisture passing through the outer skin will not collect above the damp-course. A layer of broken glass is sometimes placed in the bottom of the cavity to impede the passage of rats and mice.

Where parapets and lead gutters are adopted, a lead or asphalt damp-course should be laid on the wall immediately under them, as at D in the Plate.

In order to prevent rain damaging the woodwork of the window or finding an entrance to the room at this point, a strip of 5 lbs. milled lead about 6 inches longer than the head of the window-frame, or a double course of roofing tiles in cement, should be built into the wall immediately over it.

A kind of hollow wall is sometimes formed by fixing upright pieces of wood about a foot apart against the internal face of a wall, and covering these with laths and plaster. The uprights may be merely "grounds", about $2\frac{1}{2}$ inches wide and $\frac{3}{4}$ or 1 inch thick, nailed to plugs in the walls, or may be of larger section (3 inches by $1\frac{3}{4}$ inches, $3\frac{1}{2}$ inches by 2 inches, or more, according to the height of the room), and fixed quite clear of the wall. The latter is the better method, as there is much less liability of the wood decaying. A more durable construction consists in the use of small steel uprights of L or T section, to which reticulated or perforated sheets of metal, known as "metal lathing", are secured with wire, and afterwards covered with plaster in the ordinary way. Undoubtedly each of these three devices will hide the dampness of an external wall, but in two there is a great likelihood of decay, and in all a cavity is formed for dirt and vermin.

6. *WEATHER-TILING.*

Tile-hung walls have been frequently constructed in recent years, especially for country houses. Buildings in which weather-tiling is adopted usually have the lowest or ground story built entirely of brickwork, the upper stories only being finished with tiles.

Weather-tiles may be rectangular, or may have the lower edges shaped in various ways in order to add to the effect, as shown in fig. 55. The usual size is $10\frac{1}{2}$ inches by $6\frac{1}{2}$ inches by $\frac{1}{2}$-inch, but smaller sizes can be obtained. In the

head of each tile two holes are pierced, through which pegs or nails are driven to secure the tile to the laths or wall. Sometimes also there are two projecting "cogs" or "nibs" on the back upper edge for hanging the tile to the wood lath or other projection.

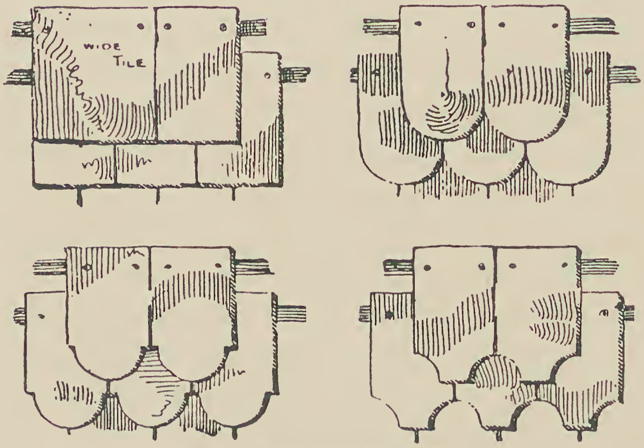


Fig. 55.—Various Shapes of Tiles.

The tiles are laid in courses, each course being overlapped by that above; the length of tile remaining exposed is said to be the "gauge" to which the tiles are laid, as at B in fig. 57. For roofs the gauge is usually 3, 3½, or 4 inches, or—to speak in slater's parlance—the tiles (if 10½ inches long) are laid to a "lap" of 4½, 3½, or 2½ inches, lap being the amount by which any course of tiles is overlapped by the *next but one* course above it. For walls the lap is usually less than for roofs, as there is less danger of rain and snow being driven between the tiles.

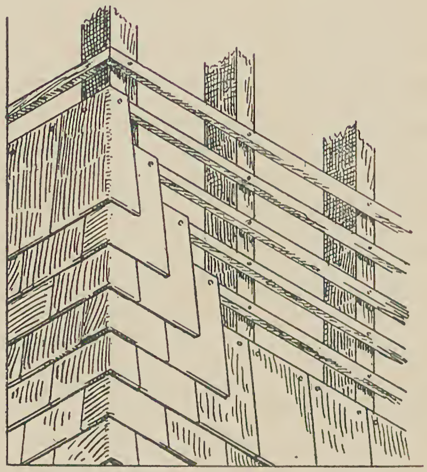


Fig. 56.—Timber-framed Wall covered with Weather-tiling.

Sometimes the tiles are slightly curved from head to tail, the upper or exposed side being convex, and the other side concave; this is done in order that the tail of the tiles may lie more closely upon those below. The upper part of each course of tiles is often covered with good mortar, to form a bed for the next course. This prevents rattling, and helps to keep the wall warmer and drier.

Timber-framed walls, as shown in fig. 56, are sometimes constructed to receive the weather-tiling, the framework consisting of horizontal sills or head-pieces with vertical battens or studs framed into them, and struts and braces as required. To the vertical studs horizontal laths (about 1½ inches by 1 inch) are nailed, to which the tiles are secured by copper or galvanized-iron nails. The framework is finished inside with laths and plaster. This arrangement is doubtless as warm and dry as a roof of similar construction, but, as the hollow spaces are likely to harbour dirt and vermin, and as the timber framing

certainly adds to the combustibility of the house, the method of construction has little to recommend it save its cheapness. Indeed, the danger arising from these timber-framed walls is so great, that they are forbidden by the building-regulations of most towns and cities.

A warmer and drier arrangement consists in covering the battens outside with boarding and felt before fixing the tile-laths, as in the better kinds of roofing, but this increases the combustibility of the structure and leaves the cavities intact. If the spaces between the studs be filled with silicate cotton or slag-wool, or with brickwork as in brick-nogged partitions, the wall will be cleaner and more fire-resisting. When all is done, however, there is the danger of the woodwork decaying, a danger which was never greater than it is to-day, as never before has there been so much young and sappy wood in the market.

Brick walls furnish a far more satisfactory backing for the tiles. They may be hollow, as shown in No. 1, fig. 57, or solid, as in No. 2, and the tiles may be secured to the walls directly by copper, zinc, or galvanized iron nails driven into the joints of the brickwork. The gauge of the tiling will, of course, be regulated by the thickness of the courses of the brickwork, and as this is, as a rule, only 3 or $3\frac{1}{4}$ inches, giving a greater lap than is necessary, the bricks are sometimes laid on edge, and the gauge becomes about $4\frac{1}{2}$ inches. This arrangement is shown in No. 1, but it cannot be recommended for exposed situations, as it gives a lap of $1\frac{1}{2}$ inches or less. A better method consists in laying the bricks flat as usual, and forming mortar-joints about 1 inch thick, so that the gauge of the tiling will be not more than 4 inches. This is a method adopted by Mr. Ralph Nevill, F.S.A.; the mortar used by Mr. Nevill for the thick joints is made of ashes and selenitic lime, "with a dash of Portland cement". The bonding of the brickwork in this kind of wall is clearly shown in No. 2.

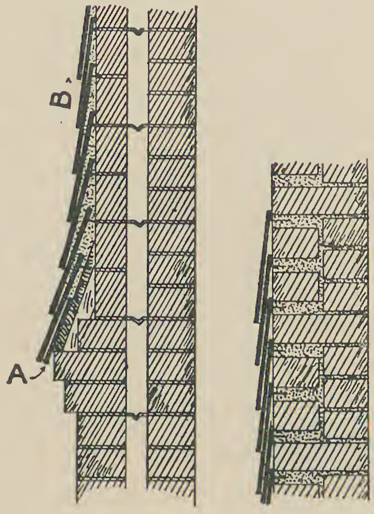


Fig. 57.—Weather-tiling on Brick Walls.
No. 1, Hollow brick wall with bricks on edge.
No. 2, Brick wall with thick joints.

Unless the mortar is of such a nature as to afford good hold for the nails, there is danger of the tiles being stripped by the wind in exposed situations. To prevent stripping, **wood fillets** are sometimes built into the brickwork every six or eight courses, and to these vertical laths are nailed, which in turn receive the horizontal tile-laths. By these means the tiles are securely held, but the

wood is sure to decay sooner or later. A better method, which is sometimes adopted, consists in nailing the tiles directly to **fixing-blocks,** specially made of a kind of concrete. Those made by Wright measure 9 inches by $5\frac{1}{8}$ inches by $1\frac{1}{2}$ inches, and are laid in continuous courses alternately with courses of bricks, as shown in fig. 58. The projection of the blocks is useful for supporting the nibs of the tiles, if the tiles are nibbed, but in any case the tiles should be nailed to the blocks.

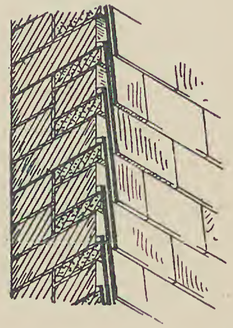


Fig. 58.—Brick Wall with Weather-tiling nailed to Fixing-blocks.

Special tiles, of suitable lengths according to the gauge, are made for the lowest course or eaves, as at A in fig. 57, and also for the top or ridge-course, while the angles of the wall are formed with angle-tiles, known as "square" or "octagonal" according as they are adapted for angles of 90° or 135°. Square angle-tiles for a salient angle are shown in fig. 56. Tiles $9\frac{3}{4}$ inches wide, known as tile-and-half, are used in alternate courses where necessary in order that the tiles may "break joint" (see fig. 55), or half-tiles are used for that purpose.

Great care should be taken that the junction between tiling and window-frames is made thoroughly water-tight with sheet-lead.

A short account of some different qualities of tiles will be found in Chapter VII. of this Section. Suffice it now to say that with good tiles properly laid, brick walls may be rendered warm, dry, and durable. Of the picturesqueness of many old and modern tile-hung houses there can be no manner of doubt.

7. *HALF-TIMBER WALLS.*

"**Half-timber work**" is the name given to that kind of external wall in which a timber framing is exposed to view, the spaces or "panels" between the timbers being filled with brickwork or plaster. Ancient half-timber houses are a notable feature of many country districts in England, and of many of the towns. In London there are still a few examples remaining, as at Holborn Bars, and in many other towns from Exeter to Manchester and Scarborough examples may be found, but the most noteworthy city in this respect is undoubtedly Chester.

At the present time the erection of half-timber buildings is prohibited in London and many other cities and towns, on account of their combustibility. Half-timber work is, however, still largely adopted for the upper walls of country houses. It consists chiefly of a framework of timbers—sills, posts, head-pieces, and straight or curved braces,—securely framed and pegged together. Almost endless variety can be shown in the arrangement of the timbers, and

picturesque effects are gained by the projection of the upper stories and gables,

Fig. 59.—Part of Entrance Front of House, with Half-timber Gable, &c.

as shown in fig. 59. The projections have a practical as well as æsthetic value, as they help to keep the walls beneath dry. A common fault is to make the

timbers too meagre and the panels too broad, a wiry, restless effect being the result.

Oak and teak are the best materials for the framing, but red deal is cheaper, although not as durable. The joint most frequently used is the mortise and tenon, the half-joint, however, being used at intersections. All the joints should be made secure with oak pegs. The timbers, if of oak, may be coated with oil, or left in the natural state, but fir is more usually stained before being oiled, or is finished with Stockholm tar, Carbolineum, or Solignum.

The panels may be filled with **brickwork,** and a $4\frac{1}{2}$-inch or 9-inch brick wall be carried along the back of the timbers, in which case the timbers are merely an ornamental facing to a brick wall. The brick panels may be finished with cement, in order to give the black-and-white effect which is usually the determining factor in the choice of this method of construction. The timbers should be grooved at the sides to afford a key for the stucco. When brickwork is not used, strong wood laths or metal lathing must be nailed between the timbers, and covered with **Portland-cement stucco.** Narrow strips of slate are sometimes used instead of the wood laths, and have the merit of durability. The framing may be finished inside with metal lathing and plaster, or with ordinary wood laths and plaster, or, for better work, may be covered with boards and roofing-felt, to which wood fillets are nailed to receive the laths and plaster.

Undoubtedly the brick filling and backing previously described give the most solid and satisfactory work, and this method of construction is now almost invariably specified by local authorities in their by-laws.

8. *EXPEDIENTS FOR THROWING RAIN OFF WALLS.*

The soaking of rain into walls may be very largely prevented by various little devices, by means of which the rain blown against the walls is diverted from its course down the walls and thrown clear of the building.

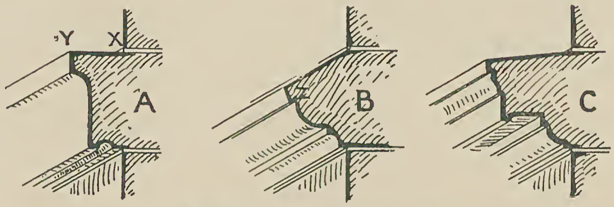


Fig. 60.—Moulded String-courses.

Moulded string-courses, as in fig. 60, will fulfil the purpose. A is a brick section which would have been all the better if the top bed from X to Y had been weathered; it will be noticed that the upper bed of the stone mould at B is shown sharply weathered, so that the water is not conducted into the wall, and that the under surface of the nose

at Z is sloped upwards in order that the water may drop freely from the edge instead of following the curve of the mould. The undercut cornice shown at C forms an effectual drip. A cornice or label mould over a window keeps the window drier. If the stone is of a kind which does not weather well, the upper surface ought to be covered with lead.

Rain caught on windows should be thrown by the **window-sills** quite clear of the walls below; in other words, the sills must project, and they are all the better if throated also. A weathered and throated stone sill is shown at L in fig. 38, page 66. Nos. 1 and 2, fig. 61, are two brick sills; the throating under

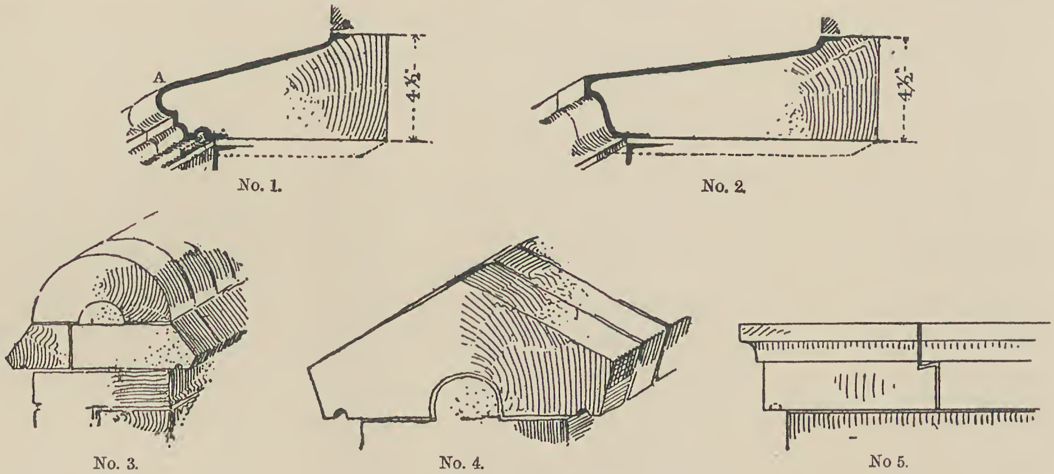


Fig. 61.—Sills and Copings.
Nos. 1 and 2, Moulded brick sills. Nos. 3 and 4, Brick coping. No. 5, Joggled joint in stone coping.

the sill A is a great improvement. Sills flush with the wall should not be tolerated, unless there is a string-course under them, which will act as a drip. Sill-bricks should be dense and hard, and should be set in good cement-mortar. Wood sills should be of oak or teak, weathered and throated.

Parapets are often the cause of damp walls. They may with advantage be built with cement-mortar, and the coping should be throated and weathered. Stone coping is shown in Plate III., and Nos. 3 and 4, fig. 61, are two good forms of brick coping. All parapet copings should be laid in cement-mortar, and the stone coping is all the better if the joints are joggled, as shown in No. 5. Under all parapets a lead or other damp-course should be formed. In brick parapets the coping often consists of hard headers in cement-mortar, laid on a damp-course formed with two courses of roofing tiles also in cement-mortar; this is known as "tile-creasing".

Projecting eaves and gables contribute largely to the dryness of the walls below.

CHAPTER IV.

MORTAR AND STUCCO.

The importance of good mortar can scarcely be over-estimated. If the mortar is bad, the wall is bad. Bad mortar allows wind and rain to penetrate, favours vegetation, easily cracks, and rapidly crumbles away, exposing the arrises of the bricks and stones to atmospheric action, and thus leading to their decay. When the face of a brick decays, it will usually be found that the mortar has first been eaten from the joints; a good mortar-joint not only makes a wall drier and stronger, but also more durable. In vain are the bricks and stones selected if the mortar also is not carefully prepared, and, be it added, used in sufficient quantity to fill the joints.

Unfortunately mortar is easily scamped, and so are mortar-joints, and as long as these matters are left in the hands of jerry-builders and unscrupulous contractors, such will be the case. It is a good plan for the building owner to provide all lime, cement, and sand; then, and then only, may he hope to have them mixed in proper proportions and used in sufficient quantity to flush the joints, and even then he will be disappointed if constant supervision be not exercised, for the ordinary bricklayer can scarcely be compelled to make a solid vertical joint: he scrapes his trowel on one arris of the brick, and leaves three-fourths of the joint absolutely devoid of mortar. Still, the temptation to do this is less when he knows that his master will not grumble at the number of hodfuls which he uses.

Mortar ought to serve at least **three purposes**: it ought to form a soft but gradually hardening bed to receive the various building-materials, so that these shall obtain an uniform bearing notwithstanding the irregularity of their surfaces; in the second place, it ought to prevent the passage of wind and rain through the joints of the walling; and, lastly, it ought to have adhesive and cohesive strength enough to bind the component parts of the wall into one solid mass. Jerry-builder's mortar seldom does more than partially serve the first and second purposes. Only the best Portland-cement mortar will thoroughly fulfil the three.

The by-laws of the **London County Council** relating to mortar are as follows:—"*All brick and stone work shall be put together with good mortar or good cement. The mortar to be used must be composed of freshly-burned lime and clean sharp sand or grit, without earthy matter, in the proportions of one of lime to three of sand or grit. The cement to be used must be Port-*

land cement, or other cement of equal quality, to be approved by the District Surveyor, mixed with clean sharp sand or grit, in the proportions of one of cement to four of sand or grit. Burnt ballast or broken brick may be substituted for sand or grit, provided such material be properly mixed with lime in a mortar mill."

As far as they go, these regulations are satisfactory; but they do not go far enough, as they do not say what is meant by "lime" and "Portland cement". The lime best suited for agricultural purposes is the least adapted for mortar, and yet in many districts the same lime is used in both cases. Indeed, "lime" may mean anything from the fattest of fat limes or the poorest of poor limes to the best ground lias lime, while "Portland cement" may be anything from very bad to very good. Certainly the by-laws are explicit enough to render penal the substitution of "gas-lime" (*i.e.* lime which has been used for the purification of coal-gas) for "freshly-burned" lime, and of filthy street-scrapings and mud for "clean sharp sand or grit",—both substitutions not unknown in the building-trade. It will be noticed also that mortar containing ashes or furnace-clinkers in lieu of sand does not comply with the regulations.

Careful experiments have been made by Mr. Charles Colson[1] to ascertain the **relative values of mortars** containing gray lime, Portland cement, and mixed lime and cement, the briquettes being kept in air. The results are summarized in Table II.,[2] and a column is added showing the relative cost per unit of strength.

In these experiments, three samples of gray lime were used, and were found to vary greatly in strength. The fractured briquettes of the lime-mortar "showed that induration . . . had penetrated only to the extent of from one-eighth to three-sixteenths of an inch, but in the majority of instances to only one-eighth of an inch. The remainder of the area, although dry and moderately hard, had become so mainly from the evaporation of the moisture originally contained in the mass, and in no sense from the absorption of carbonic acid. It was possible, moreover, to crush it in the hand without any great exertion of force."

The loam used in the tests was "yellow, fresh-dug, and rather damp". The quantity of water includes that required for slaking the lime.

The Portland-cement mortars (Nos. 4, 5, and 6) were so raw and harsh "that it would be practically impossible to use them in a satisfactory manner". In order to render them "more plastic and tenacious", lime or loam was added in the remaining tests, to the extent of one-twelfth of the volume of the sand,

[1] *Proc. Inst. C. E.* vol. liv. (1877–78, part iv.).

[2] Reproduced from the author's work on "Concrete".

this being the least quantity that would render the mortars convenient for working. Both these ingredients act injuriously on the mortars, and materially enhance the cost per unit of strength. Loam, however, is much the worse of the two. If we compare tests 5 and 11, we find that the addition of the small quantity of loam lessens the value of the mortar more than 50 per cent. The real economy, therefore, of using *clean* sand—artificially washed if necessary—is evident.

Table II.

TENSILE STRENGTH OF GRAY LIME AND PORTLAND CEMENT MORTARS, &c., AT THE AGE OF SIX MONTHS.

No.	Composition by Volume.					No. of Tests.	Average strength in lbs. per sq. inch.		Ratios of strength.	Cost per cub. yd. of mortar.	Relative cost per unit of strength.
	Portland Cement.	Gray Lime.	Loam.	Sand.	Water.					s.	
1	—	1	—	2	1·33	17	27·13	36·88	1	11·83	100
2	—	1	—	2	1·33	27	47·09				
3	—	1	—	2	1·33	27	36·44				
4	1	—	—	6	1·25	15	103·79		2·81	11·56	35
5	1	—	—	8	1·66	20	68·8		1·86	9·93	45
6	1	—	—	10	2	35	50·16		1·36	8·88	55
7	1	·5	—	6	1·5	70	73·47		2	12·2	52
8	1	·66	—	8	2	74	58·94		1·6	10·72	57
9	1	·83	—	10	2·5	85	42·34		1·14	9·75	72
10	1	—	·5	6	1	21	60·8		1·64	11·44	59
11	1	—	·66	8	1·33	25	38·43		1·04	9·82	80
12	1	—	·83	10	2	19	28·66		0·77	8·76	96

It will be noticed that a mortar composed of *one* part of Portland cement, *one-half* part of gray lime, and *six* parts of sand,—a mortar, be it said, which is sufficiently plastic for the bricklayer's purpose,—is, at the age of six months, exactly twice as strong as a mortar composed of *one* part of gray lime and *two* parts of sand, while the cost per cubic yard is practically identical. As far, therefore, as convenience in working, strength, cost, and, I may add, durability, are concerned, the advantage is on the whole greatly in favour of the cement-mortar, but it must not be forgotten that a mortar containing such a large proportion of sand is far from impervious. In any volume of sand, the interstices between the grains constitute from one-third to one-half of the bulk; it follows, therefore, that if cement to the amount of only one-sixth of the volume

of sand be added, a large proportion of voids will still remain, and the mortar cannot fail to be somewhat porous.

The wisdom of allowing no more than *four* volumes of sand to be used with cement is manifest, and it is certainly better that even a smaller proportion of sand should be used, or that a certain amount of thoroughly slaked lime should be added in order that the mortar may be more dense. The writer usually specifies cement-mortar to be a 1 to 2 mixture, and never goes beyond 1 to 3.

Excellent mortar can be made from **hydraulic lime,** such as the well-known Lias limes, mixed with sand in the proportion of 1 to 2. The lump or "shell" lime may be used, but the ground lime is much to be preferred, especially where a mortar-mill is not available. The ground lime can be distinguished from Portland cement by its yellow colour.

Selenitic limes are also preferable to common lime, but are not very largely used.

As **sand** (or some substitute for sand) forms the greater part of nearly all mortars, its importance cannot be denied. Certainly pure sand is inert, but much "sand" used in buildings is mixed with clay, iron and other salts, and organic impurities, and is detrimental to the lime or cement with which it is used. In one case about a thousand concrete blocks, in which sand containing iron-pyrites had been used, were quite worthless, as the pyrites destroyed the setting properties of the cement. The salt in sea-sand, when this is made into mortar or plaster, attracts moisture, causing dampness and often leading to efflorescence. The clay in loamy pit-sand may lessen the strength of cement-mortar as much as 50 per cent. Soot in mortar or plaster will cause stains in paint and wall-paper. Organic matter, such as dung in road-scrapings, may lead to the colonization of the house-walls with innumerable micro-organisms, which may be quite harmless or quite otherwise.

Sand from quarries, quickly-flowing streams, and little-frequented roads macadamized with coarse-grained stone, is usually suitable for mortar. Pit-sand is good, if reasonably free from clay and other impurities.

"Sand" from sluggish streams and ditches, from roads macadamized with hard, fine-grained limestone and "granite", and from foundries, had better be rejected; so also must street-sweepings.

The principal **substitutes for sand** are ashes or "breeze", brick-dust, and burnt clay-ballast. Ashes yield mortars of a somewhat weak and porous character, and may interfere with the proper setting of cement if they contain coal-dust or other impurities. Brick-dust and clay-ballast make good mortar, if they are properly burnt, hard and clean.

When a mortar-mill is not used, all **grit and lumps** should be carefully screened from the sand and lime before these are mixed, as they would tend to crack the bricks and stones if used in the mortar.

In making mortar, a little sand more or less does not matter very much when ordinary lime is the matrix, but even in this case the **measurement of the lime and sand** should be carried out with some approximation to accuracy. When, however, hydraulic lime and cement are used, the careful measurement of these and the sand, in suitable boxes or frames, must be insisted on.

Water used in mortar should be "fresh" and clean.

The proper **use of mortar** now calls for notice. It is in vain to have good mortar if it is not properly used. The one flagrant defect in brickwork is usually that the vertical joints are not flushed with mortar. The bed-joints are almost invariably entirely filled, but the ends of the bricks receive the merest scraping on the front edge, while in thick walls the sides of the filling-in bricks may receive none at all. Only the closest supervision of a resolute clerk-of-works can prevent the "brickies" from scamping their work in this way. Mortar made from cement or hydraulic lime must be mixed in small quantities and used fresh. Mortar which has once "set" to any appreciable extent cannot be remixed without loss of ultimate strength.

The **thickness of mortar-joints** in brickwork depends on the regularity of the bricks, the fineness of the mortar, and the care of the workman. In good work the joints are usually about $\frac{1}{4}$ of an inch thick, certainly not more than $\frac{3}{8}$. In stone walls there is more variation than in brick, from the thick joints of rubble and flint work to the ashlar joints scarcely thicker than a penny.

As **water** is absolutely essential not only for the initiation but also for the continuation and completion of the chemical processes involved in the setting and hardening of hydraulic limes and cements, it is imperative that the moisture should not be abstracted from the mortar too soon. Hence the necessity of protecting stucco from brilliant sunshine, or of repeatedly spraying it with water; hence also the necessity of dipping bricks in water immediately before using them, and of sprinkling a dry course of bricks with water before the bed of mortar is spread above it to receive the next course. With lime-mortar also, a moderate use of water in the same way is advantageous, although the lack of it has not so marked an effect as with cement and hydraulic lime.

The method of **finishing the joints** externally, although apparently a small matter, is by no means unimportant. The joints may be finished as the walling proceeds, or may be left rough to be raked out and finished at some subsequent

period. To distinguish the two operations, the former is sometimes spoken of as "jointing", while the latter is always known as "pointing". "Jointing" ought always to be adopted unless the mortar is of wretched quality or likely to be damaged by frost. The most common forms of mortar-joints are shown in fig. 62. A is the *flat* or *flush* joint; this joint is often finished by having a jointing-iron run along it while the mortar is wet, leaving an impression as at B, C, or D, according to the shape of the jointer. E is known as the *weather* joint, and is made by pressing the upper part of the mortar into the joint with the trowel. F is the *struck* joint, and is like the last, except that the mortar overhangs the lower course a little. The *cut* or *mason's* joint is similar to the last, but with the lower edge of the projecting mortar neatly cut with the trowel to a straight line; this is the best form of joint, as it protects the wall and does not form a ledge for holding water. H is the *mason's V-joint.*

Fig. 62.—Mortar-joints (full size).

When **pointing** has to be adopted, the mortar should be raked out to the depth of about an inch, and fresh mortar inserted and finished in one of the ways just described. The square projecting pointings, known as *tuck* and *bastard-tuck*, furnish ledges for water, and are soon destroyed; they look neat, but should not be used. In exposed situations pointing should be done with hydraulic-lime or cement-mortar, or with mastic.

The joints of internal walls are either left rough or raked out in order to afford a better key for the plaster.

In consequence of the difficulty experienced in getting the vertical joints of a wall thoroughly flushed with mortar, it is a wise precaution to have the walls run with **grout** every two or three courses. This is a very thin mixture of lime or cement, fine sand, and water. Ordinary lime is of little or no use, and with hydraulic lime and cement the less sand that is used the better, as the sand tends to settle at the bottom of the pail, and the first part of each pouring may contain most of the lime or cement, and the latter part be nearly all sand. Certainly not more than its own bulk of sand should be mixed with the lime or cement. Besides consolidating and strengthening the wall, the grout has the merit of exposing defects in the jointing by escaping at the defective places, which are at once made good by the workman in order to stop the leakage.

Walls of concrete, rubble, and common brickwork are frequently covered exter-

nally with **stucco.** Formerly the matrix was some kind of hydraulic lime, but Portland cement is now generally used, as it hardens better, and is more weatherproof and durable. The cement is made into mortar with two or three times its bulk of clean sharp sand, and applied to the wall as in ordinary plastering. The joints of the wall should be raked out to the depth of an inch to afford a key for the stucco, and the wall should be well wetted before the mortar is applied, lest it should abstract the moisture from the mortar and prevent it hardening. The first coat is scored while wet, and afterwards finished with a second and somewhat richer coat. The whole may be coloured with Duresco, or ordinary oil paint.

Ornamental features can be formed with the same materials, but projecting bricks or stones should be left in the wall to form a key for projecting architraves, cornices, and other details.

At present stucco is out of fashion, but it has its uses, chiefly perhaps in the repair of old buildings; certainly it has rendered many a damp wall dry, and preserved much brickwork which would otherwise have perished.

Rough-cast in its cheapest form is executed by throwing a thin paste of hot lime, coarse sand, and grit or fine gravel, upon a wet plastered surface, but lime rough-cast is neither weatherproof nor durable. The best method is to render the wall with Portland-cement mortar, and to apply to the scored surface a coat of clean fine gravel which has been steeped in a thick grout of neat Portland cement. Usually the rough-cast, after it has set, is brushed over with a wash of water mixed with neat cement, or with lime and tallow, or with lime, white copperas and oil. Ochre and other colouring ingredients can be added.

CHAPTER V.

INTERNAL WALLS AND PARTITIONS.

Internal walls are occasionally built of **stone** or **concrete**, but more frequently of **brick,** the thickness as a rule depending mainly on the amount of money available. Brick walls only $4\frac{1}{2}$ inches thick are often used, but certainly a greater thickness is to be desired. Thick walls have the advantages of strength, increased fire-resistance, and of deadening sound.

The word "**partition**" is not easy to define. Formerly it was applied exclusively to structures of wood, such as the ordinary boarded partition, and

the framework of wood posts, &c., known as "studding"; but latterly it has been applied to various special kinds of brick and concrete blocks, devised for the purpose of providing light but strong and fire-resisting walls in the upper stories of buildings.

Studding consists of upright wood posts resting on sills secured to the floor-joists or floor-boards, or—in the case of lofty and heavy partitions—to beams provided for the purpose. The studs or posts (for ordinary partitions not exceeding 10 feet high) may be anything from $4\frac{1}{2}$ inches by 3 inches to 3 inches by $1\frac{3}{4}$ inches, fixed about one foot from centre to centre, and braced across to give rigidity. The partition is usually covered on both sides with laths and plaster, like an ordinary ceiling. There are grave objections to these lath-and-plaster partitions: they are inflammable, and easily damaged; they harbour vermin, and transmit sound with great facility. In these days of steel joists, it is an easy matter to substitute a brick wall in almost every case. Certainly studding should not be tolerated between a W.C. or bathroom and a bedroom or sitting-room, unless it is brick-nogged.

Formerly **brick-nogged partitions** were much in vogue, *i.e.* partitions with the spaces between the timbers filled with bricks, but they are less frequently used nowadays, as it is simpler, cheaper, and better to dispense with the wood framing and to provide a steel joist to carry the brickwork.

Where exceptionally **light fire-resisting partitions** are required, special contrivances may be adopted instead of woodwork; as, for example, pumice bricks, hollow bricks, hollow concrete blocks, thin concrete walls (the concrete composed of Portland cement and breeze). One of these special kinds of partition is shown in fig. 63. It is constructed of fire-resisting blocks 5 feet 5 inches long, 10 inches high, and 2 inches thick, each block having five small holes running throughout its length to reduce the weight. The blocks are secured to floors, walls, and ceilings by means of **U**-shaped metal clamps, and to each other by **Z**-shaped clamps "forced into slits cut by a saw in the adjoining edges of the blocks, one half of the clamp entering one block, whilst the other half enters the adjoining block". The partition is afterwards plastered on both sides, the plaster making the total thickness about 3 inches. The weight is about one-fourth the weight of a $4\frac{1}{2}$-inch brick wall. Many other partitions of a light but fire-resisting character are now used, such as the "Mack", the "Kulm", and Shepwood's. Plaster of Paris is often used as the matrix. Sometimes

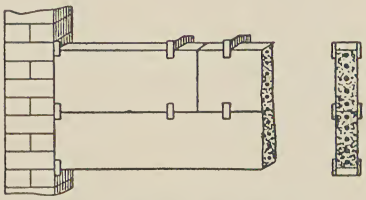


Fig. 63.—"Hygienic" Block Partition.

partitions are formed of two layers of metal lathing attached to the two sides of a very light iron or steel framework, and covered on both sides with good plaster; the plaster forced through the meshes of the lathing renders the partition practically solid. The Expanded Metal Company dispenses with one layer of lathing by erecting a series of tightly-drawn vertical wires and interweaving the sheets of expanded metal horizontally between them; thus, the first sheet will pass in front of the first wire, behind the second, in front of the third, and so on, while the sheet above it will pass behind the first wire, and in front of the second.

CHAPTER VI.

FIREPLACES AND CHIMNEYS.

One of the most important features of a British home is **the open fire.** When properly arranged, this is not only a cheerful and pleasant means of warming a room, but it is also an excellent ventilator, and for this reason a fireplace ought to be provided in every room intended for occupation, especially in every bedroom. On the proper design and construction of the fire-receptacle, and of the shaft for carrying away the products of combustion, the comfort and cleanliness of the room (and indeed of the house) very largely depend. A smoky fireplace, however, leads not only to filth and discomfort; it may also be the cause of colds and sore throats, besides rendering the room unfit for occupation during a great part of the year.

In **the perfect fireplace and chimney** there is a continuous, steady, and not too strong up-draught. The attainment of perfection in chimneys, as in everything else, is a difficult matter. Something must be allowed to skill in design, something to careful workmanship, and something also to happy chance. Here are a few hints which may be of service:—

Firstly, **as to the room itself**—

1. Provision should be made for the inlet of air otherwise than by the door. If there are no chinks in windows, doors, and floors, the fire cannot draw unless the door or window is open: the chimney is not an air-pump.

2. The fireplace should not be too near the door, or there may be puffs of smoke when the door is quickly closed,—not to mention draughts.

3. The fireplace is not well placed against an external wall, for reasons to be given hereafter.

Secondly, as to the fireplace—

1. Dog-grates and hob-grates are apt to smoke on account of the wide open space between the fire and the flue.

2. The old-fashioned register-grates with the outward splay above the flue-opening seem made for the purpose of allowing the smoke to float into the room.

3. Some modern firegrates smoke because the backs project forward too much. A better draught is obtained if the products of combustion have a direct vertical course from the fire to the flue.

4. The more fire-clay that is used in the construction of the fire-box, and the less iron, the better.

5. An open space behind the fire-grate communicating freely with the room and the flue—which is often the case with iron grates—is apt to interfere with the proper draught of the fire.

Thirdly, as to the flue—

1. The gathering from the fireplace opening to the flue should be short: a large space at the foot of the flue may make the draught sluggish for some time after the fire is lit. One of Benison's fire-clay smoke-receivers may with advantage be used instead of the usual oversailing courses of brickwork or sloping flagstone; the smoke-receiver, as will be seen from fig. 68, is shaped like a wide, shallow keystone, through which is a hole, large at the bottom, and tapering upwards to the size of the flue above.

2. The flue should not be too large; a flue 14 inches by 9 inches is large enough for all ordinary household fires, kitchen included, and for most fires smaller flues are better, especially if formed with fire-clay tubes.

3. Fire-clay tubes—which are made circular, square, oblong, and square and oblong with rounded corners[1]—increase the draught of a chimney by reducing friction and retaining heat, and also lessen the risk of fire; they should be used wherever the cost can be afforded. The cavity between them and the brick-work should be filled with grout.

4. Where pipes are not used, the flue must be carefully pargeted with mortar and all the angles neatly rounded; this helps to keep the flue warm, reduces friction, and lessens the risk of fire, and of smoke escaping into the rooms or upper fireplaces.

5. Flues against external walls are often chilled by the cold air outside, and draught is stopped in consequence or greatly retarded; hence flues are best

[1] Tubes with two passages (one for smoke and the other for air) are also made, the air-passage commencing in some room which it is intended to ventilate and terminating at an outlet grate in the side of the chimney-stack. It is always better, however, to provide a separate flue for ventilation, as a better outlet can be provided at the top.

placed against internal walls. Where the flue is necessarily against the external wall, the thickness of the wall must not be reduced at the back of the flue, as is so often done, but rather increased, and the flue ought to be lined with fire-clay tubes.

6. Slight bends in flues are an advantage; a perfectly straight flue will draw more fiercely than a curved one, but is more liable to sudden gusts of down-draught. On the other hand, long and sinuous bends must be avoided, especially if the curves approach the horizontal, as the friction of the smoke is considerably increased, and there is danger of the pargeting on the upper side of the bend being scamped. Where the flue makes a smaller angle with the horizon than 45 degrees, soot-doors must be provided.

7. The flue must be unobstructed throughout its length. It is not an uncommon matter for a flue to be partly blocked with mortar, bricks, &c., dropped into it by careless workmen and left there. A good plan is to draw a bundle of hay or rags up the flue as the work proceeds, so that anything falling into the flue is at once stopped. Or the flue may be "cored", *i.e.* a wire brush or other "core" is passed through it after the chimney has been built.

8. One common cause of obstructions in flues is the bad bonding of the flue divisions with the brickwork in front and behind. In many cases there is absolutely no bond at all, and a clumsy or vicious chimney-sweep may easily displace a brick and so throttle the flue. Flue-pipes are advantageous in this respect, as they cannot be easily dislocated; moreover, many flues lined with them never require to be swept.

Fourthly, as to the chimney-stack—

1. The best position for a chimney-stack is on the ridge of the roof, some distance from the gable end. The slope of the roof not far from the ridge is also good, but the apex of a gable and the eaves of a roof are both bad. The probabilities are that chimneys in these two positions will not be satisfactory, unless they are carried up to a greater height than would at first sight appear to be necessary.

2. A chimney which is overtopped by a building, tree, or rock, in close proximity, is sure to smoke when the wind is blowing over the obstruction, unless an efficient wind-guard at the top of the flue is provided; and what will prove an efficient wind-guard for a particular flue, who can predicate?

3. The walls of chimney-stacks should not be too thin, as thin walls chill the flue and check the draught; this is especially the case with lofty stacks. Here again the flue-pipes will be of service, and the walls may with advantage

be 9 inches thick instead of the usual $4\frac{1}{2}$ inches. When the walls surrounding the flue are 9 inches thick, there is no difficulty in obtaining good bond, but when they are only $4\frac{1}{2}$ inches thick, much neat cutting is required, as shown in fig. 64, which gives two courses of a brick chimney-stack in the usual stretcher-bond. Frequently in stone chimney-stacks with brick flue-divisions, no attempt at bond is made, unless the stone is lined throughout with brick.

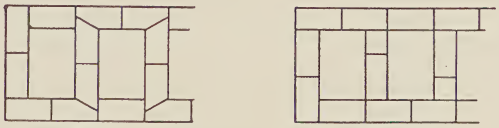


Fig. 64.—Two Courses of $4\frac{1}{2}$-inch Brick Chimney-stack in Stretcher-bond.

When ornamental brick stacks are desired, specially-moulded bricks must be obtained, carefully designed to give proper bond, as shown in figs. 65 and 66.

4. Short flues are somewhat apt to smoke, a fault often remedied by raising the chimney-stack, or fixing a tall-boy on the top of it. By-laws frequently insist that every chimney-stack must be carried at least 3 feet above the highest point at which it leaves the roof. This is intended as a precaution against fire; it is useful also in increasing the draught of the chimney. In any case, however, the chimney should be carried higher than the ridge of the roof.

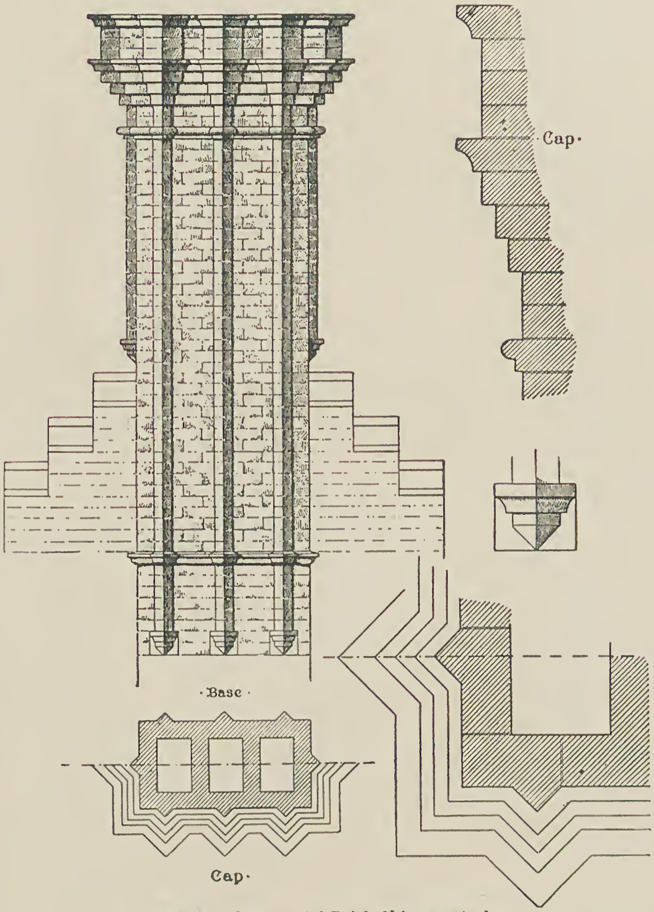


Fig. 65.—Ornamental Brick Chimney-stack.

5. Each flue should be finished in such a way as to separate it from its neighbours, so that the smoke from one flue does not find its way down the next not in use. This may be done by means of the simple cone-terminal, or short chimney-pot, or by one of the countless host of cowls, pots, and wind-guards. Contrivances of this sort must sometimes be used to prevent down-draught; in many cases a simple mushroom

will prove effective, while in others a pot with a number of ducts leading downwards from the inside to the outside will reduce or prevent a down-draught.

The subject of **fire-grates** will be treated in the section on Warming, but a few words must be said here respecting them. There are three main varieties of grate, each requiring a somewhat different treatment of the fireplace; these

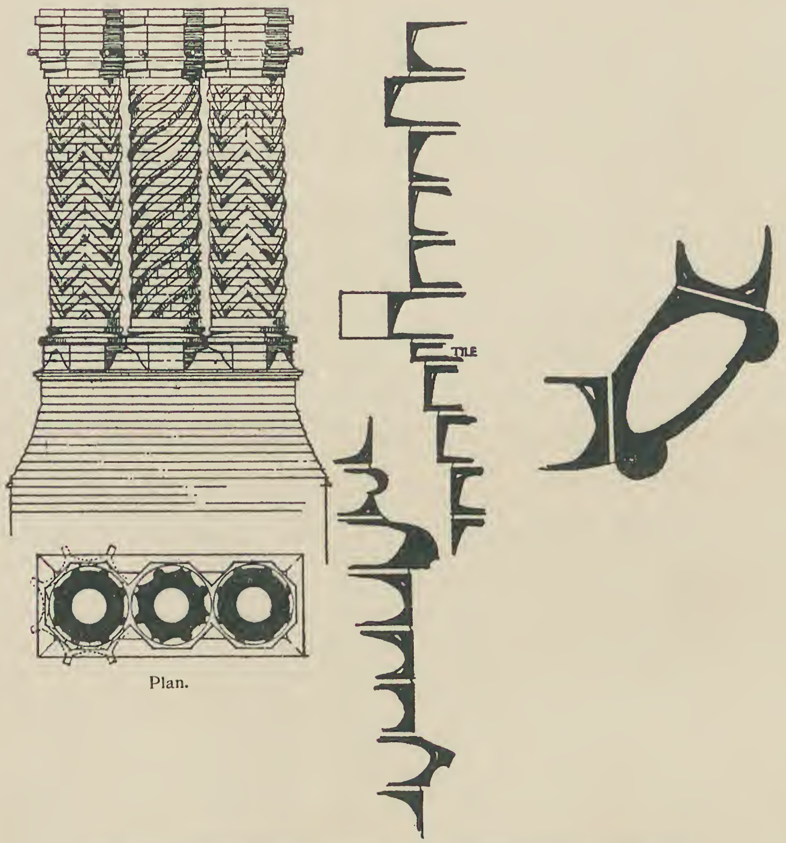


Fig. 66.—Ornamental Brick Chimney-stack, with detached Shaft for each Flue.

are the dog-grate, the hob-grate, and the ordinary grate enclosed on three sides and open at the front.

The **dog-grate,** or (as it is sometimes termed) "fire-basket", is a detached receptacle for fire, placed in a recess, from the top of which the smoke-flue ascends. The grate is usually of iron, with perhaps some portions of brass or copper, and in the better kinds the back and sides are lined with fire-clay. The heat radiated by dog-grates is small in proportion to the amount of fuel consumed, and as they are also provocative of dust, and somewhat apt to smoke, they are more suitable for burning wood than for coal.

The recess for the dog-grate is usually formed with glazed bricks, which are

HALL, "WOODLEA", WOLDINGHAM.

SITTING-ROOM, "THE DOVER", POLING, NEAR ARUNDEL.

DOG-GRATES AND INGLE NOOK.

G. L. SUTCLIFFE, A.R.I.B.A., ARCHITECT.

often of small size, measuring only $4\frac{1}{2}$ inches by 2 inches, or 6 inches by 2 inches, on the face, and 3 inches on the bed. Sometimes ordinary unglazed facing-bricks are preferred. Fig. 67 gives a plan and elevation of a dog-grate recess; the width and height of the recess may be varied, but the depth is usually 18 inches. The sides of the recess may be square, as at A, or canted, as at B, the latter being the better form. Dog-grates in ingle-nooks and in large recesses are often placed under metal canopies, as shown in Plate IIIA. The canopy ought to extend well over the dog-grate in order to collect the smoke, and as the metal is heated by the smoke and fire, it helps to warm the air of the room by conduction.

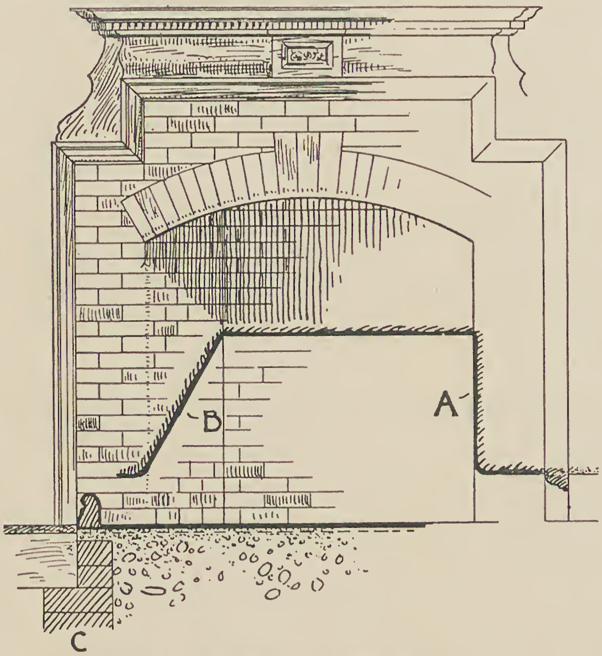


Fig. 67.—Plan and Elevation of Recess for Dog-grate.

The **hob-grate** is closely akin to the dog-grate, and partakes of the family faults. The recess is formed with ordinary brickwork to the top of the hobs, and above with glazed bricks or tiles, or with cast-iron plates. The breasts and arch may be of similar character to those for a dog-grate; the hob-grate, however, must be accurately fitted to the opening, or *vice versa.*

The name of the "**ordinary**" **grate** is legion—from the old-fashioned, cast-iron register-grate to the newest "slow-combustion" fire-receptacle constructed wholly of fire-clay. Ordinarily, a simple opening is formed in common brickwork, as shown in fig. 68, the opening being spanned either by a stone lintel or by a brick arch. The latter is often supported on a $2\frac{1}{2}$-inch by $\frac{3}{8}$-inch wrought-iron bar split at the ends, and turned up and down into the brickwork of the jambs. Into the recess a fire-grate is set, with such brickwork as may be necessary; and the common brickwork around the grate is faced with tiles, or slate or marble mantels, in hundreds of different ways. The recess is about 3 feet high and 3 feet wide for large rooms, while for smaller rooms it may be made as narrow as 1 foot 6 inches. The greatest width required for some of the best modern fires is 2 feet 3 inches or 2 feet 8 inches. In the illustration the brickwork at the back and sides of the chimney-breast is shown 9 inches thick, and that

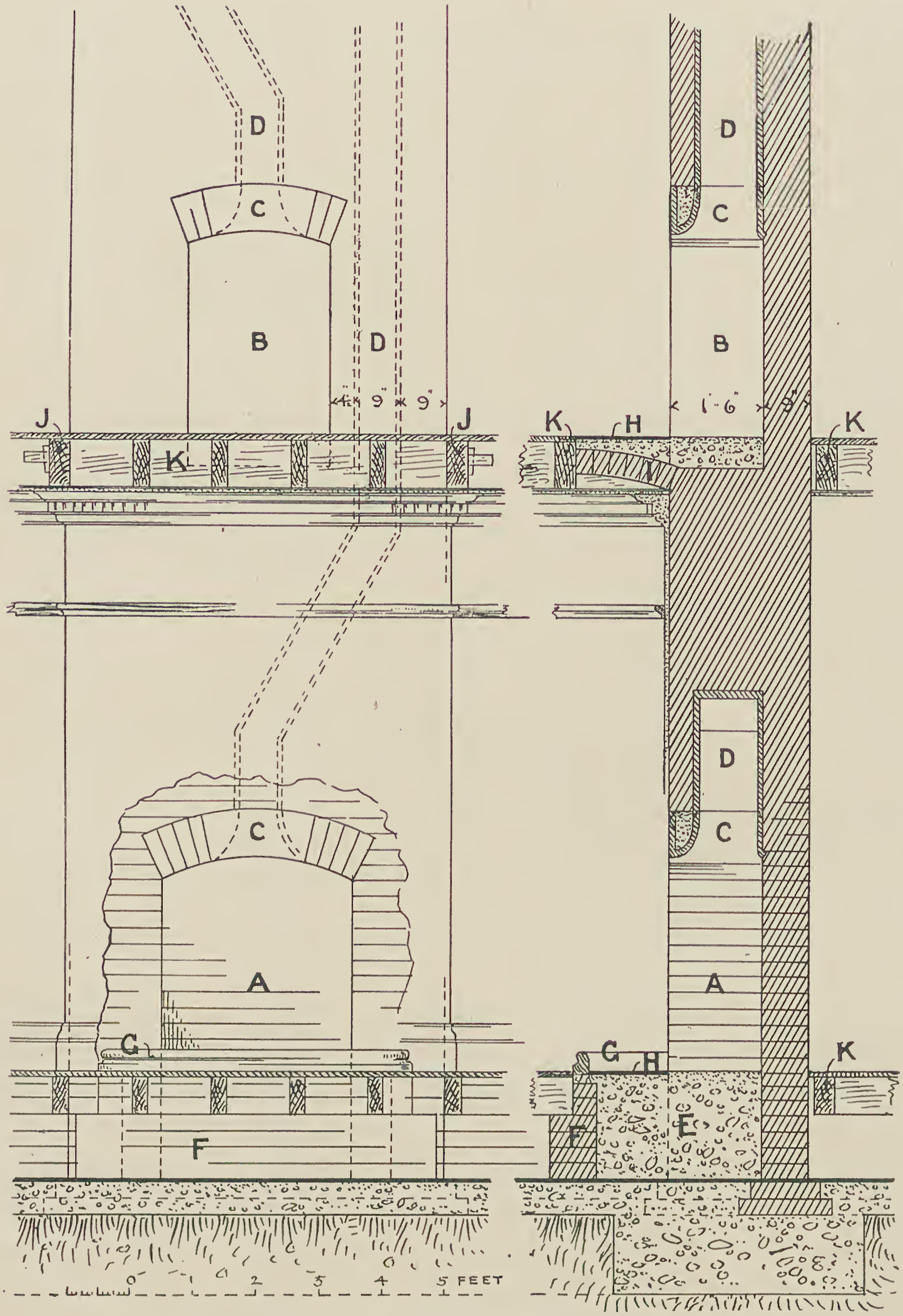


Fig. 68.—Elevation and Section of Chimney-breasts and Flues for Sitting-room and Bedroom.

A, sitting-room fireplace; B, bedroom fireplace; C, smoke-receivers; D, smoke-flues lined with fire-clay tubes; E, solid concrete hearth; F, fender wall; G, fender curb; H, tiled hearths; I, brick trimmer-arch; J, trimming joists; K, trimmers.

in front only $4\frac{1}{2}$ inches, but in good work a thickness of 9 inches should be maintained throughout; this not only lessens the risk of fire, but gives a

firmer base for the chimney-stack, and affords a better bond for the flue-divisions.

Many of the glazed-ware mantels and fireplaces are made to fit the ordinary fireplace opening shown in fig. 68, but for some of these a special arrangement of the back hearth is required, as shown in fig. 69, which is a section of the "Rational" fireplace,—a fireplace which possesses several advantages, but which necessitates care in the construction of the hearth when used in connection with wood floors, as great heat is developed under the hearth.

In order to avoid the danger of fire, the brickwork at the back of a fireplace ought to be at least 9 inches thick. When the back is only $4\frac{1}{2}$ inches thick, wood plugs, driven into the joints of the brickwork to secure the skirting on the other side of the wall, may penetrate to the flue, knocking off the pargeting and leaving the wood exposed to the heat of the fire-back. It is particularly necessary to bear this warning in mind when slow-combustion grates are used, as these develop great heat in the back and sides of the fire-receptacle.

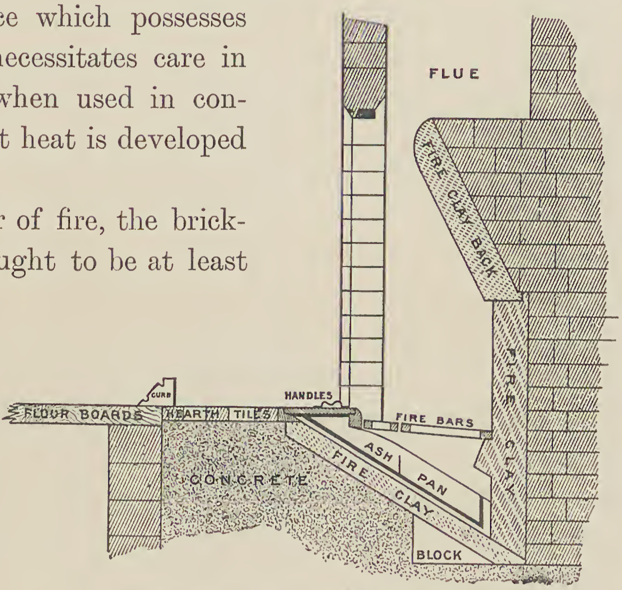


Fig. 69.—Section of the "Rational" Fireplace.

Great care must also be taken that wood **floor-joists and roof-timbers** are not allowed to enter the brickwork of flues and fireplaces. The trimming of the floor-joists in front of a chimney-breast is now never entirely neglected, but it is equally necessary that the joists bearing at the *back* of the breast should also be trimmed, as illustrated in the section in fig. 68. Corbels should be provided for the ends of roof-timbers near flues.

Wood mantel-pieces are also a source of danger. In my own office I was one day surprised by a smell of burning paint and wood, and found that a live coal falling on the hearth had set fire to a piece of paper, and this in turn had set fire to the woodwork of the mantel. Care should be taken that all wood is removed from the metal of the grate by means of tiles or marble slips, the further the better; a glazed-ware fender curb, with the woodwork (if any) extending to the floor outside the curb, is safer than a movable fender.

Wood mantel-pieces, besides being a source of danger from fire, may prove unsightly in consequence of warping and shrinking. To prevent this unsight-

liness the wood must be of the best, and the mantel must not be delivered at the building for some weeks after the plastering has been completed; indeed, the dampness of the walls is more often at fault than the quality of the wood. Painting the back of the woodwork reduces the amount of absorption from the walls, and, therefore, may prevent warping.

The faulty construction of **hearths** is probably the cause of more household fires than any other defect. When the hearth rests on the solid ground or on the ground-layer of concrete, or when the floor is formed entirely of concrete or other fire-resisting materials, the hearth cannot well be a source of danger; when, however, the floor is constructed of wood joists and boards, danger is inevitably present.

Until recent years the visible portion of a hearth was usually of flagstone in two pieces, known respectively as the "front" and "back" hearth. The back hearth rested on the brickwork of the chimney-breast beneath, while, in jerry-buildings, the front hearth was carried by fillets nailed to the trimmer and trimming joists, or by shallow wood joists extending across the trimmed space. An example of this kind came under my own observation some years ago; the hot ashes from the fire above, passing through the joint between the front and back hearth, *twice* set fire to the pitch-pine ceiling below. Fortunately in neither case was very much damage done, but sufficient at any rate to have paid a dozen times over for the construction of a proper hearth when the building was erected. After the second fire the hearth was bedded on concrete, and no further damage has been done.

Sometimes a counterfloor is constructed under the hearth with shallow wood joists and boards, and covered with mortar or fine concrete, on which the hearth, whether of stone or tiles, is bedded. This is an improvement on the method previously described, but it is not entirely satisfactory. A better and more general form of construction is delineated in fig. 68, p. 140, a trimmer-arch of brick, marked I, being turned from a skewback cut in the chimney-breast to the trimmer, and the space above being filled with cement-mortar or fine concrete, floated to receive the hearth-tiles. A more recent invention consists of a curved iron or steel plate fixed to the trimmer and wall, and covered with concrete, as illustrated in fig. 70. The plates are made 1 foot 3 inches, 1 foot 6 inches, and 2 feet long, and with a span of 1 foot 2 inches and 1 foot 6 inches.

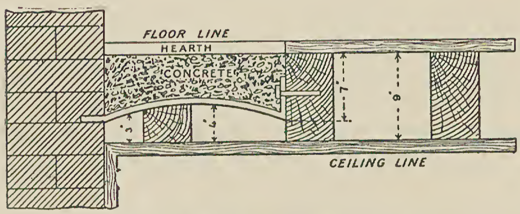


Fig. 70.—Moore's patent Hearth-boxing.

Concrete alone is sometimes used, fillets being nailed to the trimmer and trimming joists, and a chase being cut or formed in the brickwork to support it. The concrete is deposited on a temporary platform of wood, which is allowed to remain in position for a fortnight or more (till the concrete is sufficiently hard), and is then removed.

Hearths are often finished with tiles, which are laid in cement on the floated surface of the concrete below.

The construction of hearths in boarded rooms on the ground floor is an easy matter. A fender wall of brick is usually built up to the edges of the hearth, and on it the floor-joists rest, as shown in figs. 67 and 68. The space under the hearth is filled with concrete on a bed of brick rubble.

Glazed **fender-curbs** of various sizes, colours, and designs are now made, and are frequently used in place of movable metal fenders. They are shown in several of the foregoing illustrations. The ends of the curbs should be ground perfectly true, and secured to each other with dowels, the whole curb being bedded in cement-mortar. It is best to make the concrete hearth large enough to receive the curb; where this is not done, a chase $\frac{1}{2}$ inch deep should be cut in the floor-boards, and clout-nails driven, not quite to the head, in order to afford a key for the cement-mortar.

CHAPTER VII.

ROOFS.

There are **two classes of roofs**—flat and pitched. Flat roofs (so-called) have only the slightest inclination, merely sufficient to allow rain-water to flow to the outlets. They are usually of wood covered with lead, copper, or zinc, or of concrete and other materials covered with asphalt. Pitched roofs have usually a framework of wood or iron or other materials covered with felt, galvanized iron, lead, zinc, copper, glass, slates, or tiles. Pitched roofs are almost invariably adopted for houses in these islands, as they throw off the rain and snow more quickly, and are considered more beautiful. "Flats", however, frequently occur over bay-windows, porches, and out-buildings, and over some parts of the main building. In fig. 71 the *smallest* inclinations which may be given to different roofing materials are shown.

1. *FLAT ROOFS.*

Flat roofs are now being constructed for board schools, blocks of workmen's dwellings, and other buildings where space for recreation and other purposes is desired.

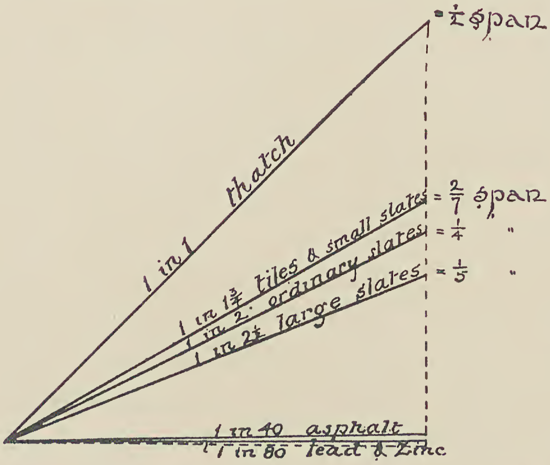


Fig. 71.—Diagram showing the smallest inclination for various roof-coverings.

The framework of a **lead flat** consists usually of wood joists and battens or "firrings", covered with boards one inch or more in thickness, as shown in fig. 72. A gutter, not less than $2\frac{1}{2}$ inches deep at the shallower end, is formed along one or more sides of the flat, as at D (fig. 72). The boards should be tongued and grooved (in order to prevent warping), of uniform thickness, and laid with their length in the direction of the fall of the flat; where uneven, straight-jointed boards, laid transversely, are used, the lead may eventually be cracked by the edges of the boards. As lead expands and contracts considerably with the rise and fall of temperature, it cannot be simply nailed to the boards like felt, but must be allowed free play; otherwise cracks are sure to occur

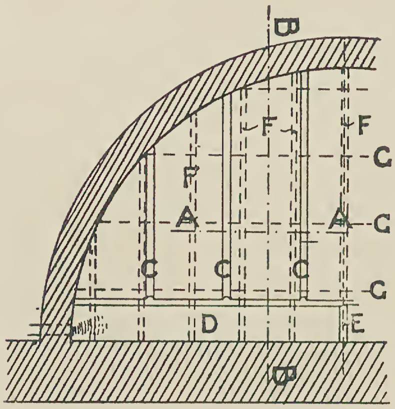


Fig. 72.—Half-plan of Lead Flat over Bay-window. C C, rolls; D, gutter; E, drip in gutter; F F, 9″×2″ tapering joists; G G, $3\frac{1}{2}$″×2″ purlins.

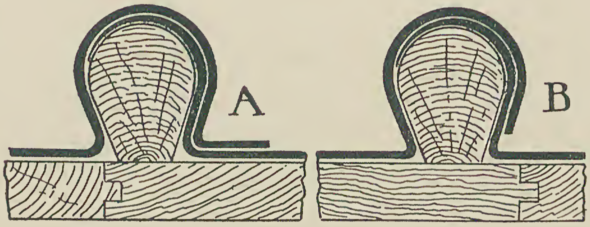


Fig. 73.—Transverse Section through Lead Flat (on line A A in fig. 72). A, with overcloak dressed on the flat; B, with overcloak cut clear of the flat.

sooner or later. To allow the necessary freedom, wood-rolls are generally used, as shown in fig. 72, and the lead is cut into strips not more than 3 feet 6 inches in width, one edge of the strip being nailed to one of the wood-rolls, the other edge being dressed over the next roll, but not nailed or fixed in any way

It is better that the overcloak should extend an inch along the flat, as at A, although this is not often done in the North of England.

Wood rolls are usually 2 or $2\frac{1}{2}$ inches in diameter, and fixed at distances varying from 1 foot 6 inches to about 3 feet from centre to centre. Certainly no greater distance than 3 feet should be allowed, and smaller distances are

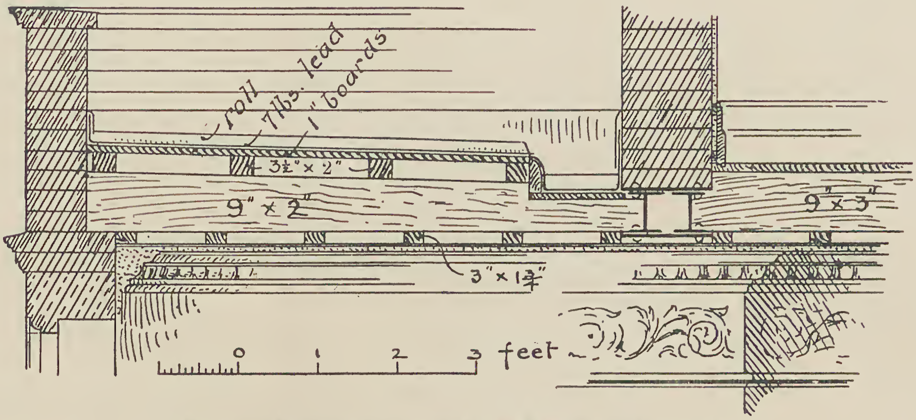


Fig. 74.—Longitudinal Section through Lead Flat (on line B B in fig. 72).

preferable. The sheet-lead is manufactured in various widths up to 9 feet, and the spacing of the rolls should be regulated by the width of the sheet, the size of the rolls, and the overlap of the lead. Thus, sheet-lead 8 feet wide may be cut into three strips 2 feet 8 inches wide. If 4 inches along one edge of each strip be dressed up to form the undercloak on a roll with a base of $1\frac{1}{4}$ inch, and 7 inches along the other edge be dressed up to form the overcloak and splash-lap, the flat portion of the strip will be 1 foot 9 inches wide, and this gives the distance *apart* of the rolls, which will therefore be 1 foot $10\frac{1}{4}$ inches from centre to centre.

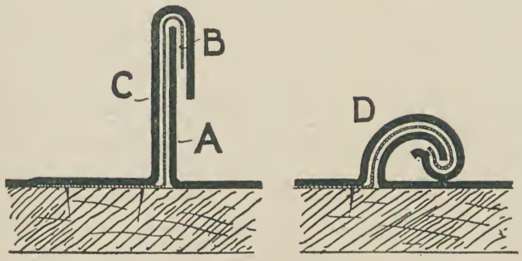


Fig. 75.—Lead Seam-roll.

Seam-rolls are sometimes used. These do not require wood cores, and are therefore adapted for curved surfaces, where the formation of curved wood rolls would be somewhat costly, but they cannot be used where likely to be trampled on. They are formed, as shown in fig. 75, by dressing up one edge, A, of one of the sheets of lead to be united. Tacks or tingles of lead or thin copper, B, are then nailed at intervals of 3 or 4 feet to the boarding alongside the lead, and turned down over it. The edge of the adjacent sheet of lead, C, is set up and turned over till it reaches about half-way down the undercloak. The two edges are then dressed

together, and finally bent into the form of a roll, as shown at D, a temporary wood core being sometimes used in the operation. If lead tacks are used, small sinkings should be cut in the boards to receive them.

It is usually said that **the fall or inclination of lead flats and gutters** should be not less than $1\frac{1}{2}$ inches in 10 feet; wherever possible, however, a greater fall should be given, say 2 or 3 inches in 10 feet. A fall of 3 inches in 10 feet is only 1 in 40, not by any means an excessive slope for the conveyance of dirty rain-water and melting snow. Lead is sometimes used for covering roofs of ordinary pitch, but cannot be recommended, as, in consequence of expansion aided by gravity, and contraction opposed by gravity, it gradually "crawls"

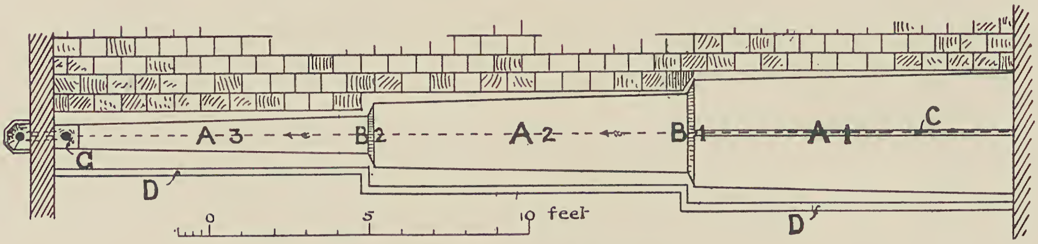


Fig. 76.—Plan of Lead Gutter 30 feet long.

A 1, A 2, A 3, lead "flats" sloping $1\frac{1}{2}$ in. in 10 feet; B 1, B 2, drips 3 in. deep; C, roll; D, tilting fillet for slates; G, cesspool.

down the slope. The lead on the roof of Bristol Cathedral crawled 18 inches in 2 years.

The evil effects of the transverse expansion and contraction of the lead sheets may be avoided by means of the longitudinal joints just described, but the lead may be cracked by longitudinal expansion and contraction if the end or transverse joints are not properly made. Particular care must be observed in the construction of **long gutters,** that the transverse joints are sufficiently numerous, and are not nailed or soldered or fixed in any way. Fig. 76 is the plan of a lead gutter 30 feet long, and fig. 77 the transverse section of the lowest "flat". The transverse joints, B 1 and B 2, are made by means of drips, which must never be more than 10 feet apart, or less than $2\frac{1}{2}$ inches deep. Two good forms of drip are shown in fig. 78. Care should be taken that there are no sharp angles to cut the lead, and that the boarding is cut out to receive the edge of the lower sheet, otherwise a slight ridge will occur, which may result in the cracking of the upper sheet. The upper sheet at A extends an inch or more on to the lower flat. In order to economize lead, the drips and fall in long gutters are often reduced to such an extent that solder has to be used in order to make the joints water-tight. This practice is most reprehensible.

In long gutters on roofs of low pitch the uppermost length of the gutter may

be so broad that it will not be wise to lay it in one piece. A longitudinal roll-joint is then necessary, as shown at C in figs. 76 and 77. At the outlet end of the gutter a small box or "cesspool" is often formed, as at G, fig. 76, and lined

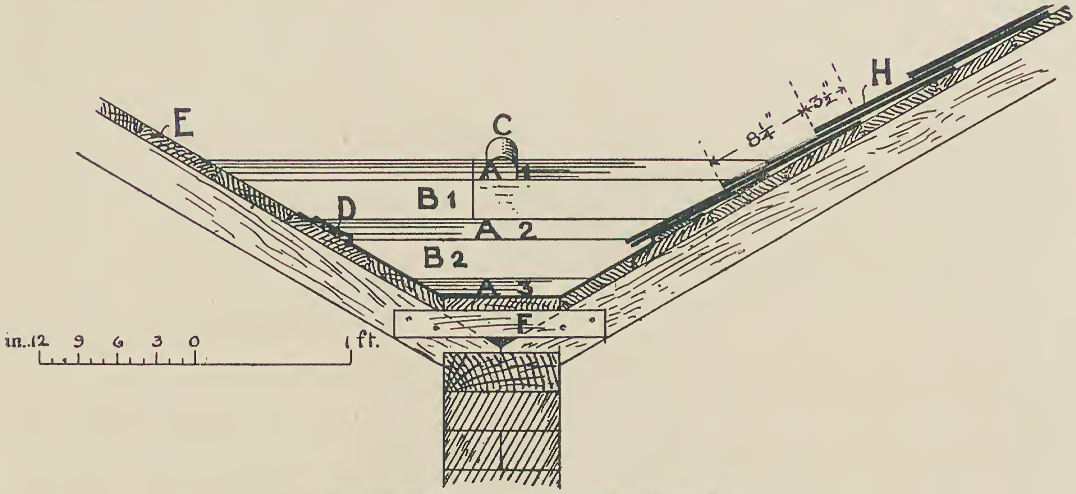


Fig. 77.—Transverse Section through Lead Gutter.

A, B, C, as fig. 78; D, tilting fillet covered with lead; E, roof-boarding covered with felt or waterproof paper; F, gutter-bearer; H, slates 20 in. long laid to a lap of $3\frac{1}{2}$ inches.

with lead, out of which a 3- or 4-inch lead pipe is taken through the wall to the rain-water pipe, an overflow (B, fig. 79) being provided at a higher level.

The lead should extend up the roof-slopes to a *vertical* height of not less than 6 inches above the flat portion of the gutter. In roofs of low pitch this entails a great quantity of lead, and it may be advisable to construct a box gutter with vertical sides in lieu of the ordinary gutter.

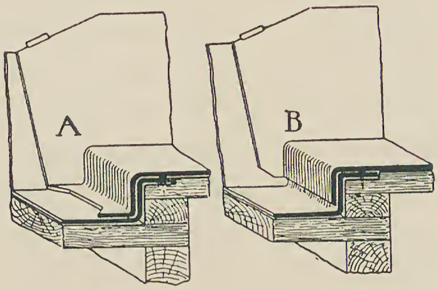


Fig. 78.—Two Varieties of Lead Drip.

The junctions of lead flats and gutters with walls and chimneys must be carefully made by means of **lead upstands and flashings**, secured into the joints of the brickwork with lead wedges, and pointed with cement or mastic. The lead used for flats and gutters should weigh 6 or 8 lbs. to the square foot, while that for aprons and steps may be 5 lbs.

Felt is sometimes used under lead flats, as under slates and tiles; but as it is difficult to dress the lead properly on such a yielding material, plumbers prefer waterproof paper.

Over all gutters in roofs **snow-boards** should be fixed. These consist either of longitudinal bearers to which transverse laths are nailed, or (better) of trans-

verse bearers arched to allow the passage of water down the gutter, and covered with laths laid in the direction of the gutter, as shown in fig. 79. The laths should not be more than $\frac{1}{4}$ inch apart. The object of snow-boards is to keep the snow quite clear of the gutter, and so afford a free passage for water. When the snow rests on the gutter itself the passage of water is impeded, the snow forming a dam, which raises the water over the top of the leadwork and so drives it into the rooms below.

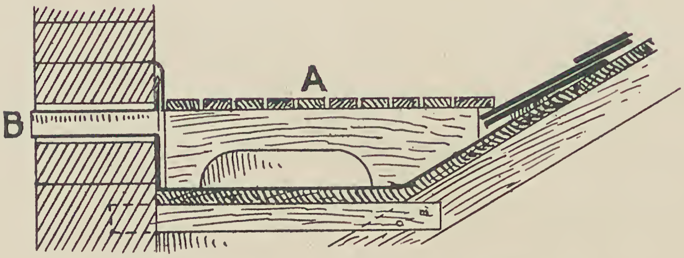


Fig. 79.—Transverse Section of Parapet-gutter with Snow-boards.
A, snow-boards on arched bearer; B, overflow in case the rain-water pipe is stopped.

Zinc is sometimes used instead of lead, being cheap, and is laid in much the same way, great care being taken to allow free play for expansion and contraction. The sheets used for roofs weigh from 1 to $1\frac{1}{2}$ lbs. per square foot, the heaviest being used for flats.

The best zinc is supplied by the Vielle Montagne Company, and this, if properly laid, will last perhaps 20 or 30 years. As a general rule, however, zinc cannot be recommended, as the inferior kinds are soon corroded by the smoky and acid-laden air of towns, and by contact with other metals (iron, copper, lead), and with lime.[1] It is combustible, but has the merit of lightness.

Copper is a far more durable material than zinc, and being used in thinner sheets, it provides a lighter roof-covering. Copper sheets weighing only 16 or 18 ozs. per sq. foot are quite thick enough for flats, and in this respect the material has a great advantage over lead, which ought not to weigh less than 6 lbs. per sq. foot. Some of the characteristics of the three materials are given in the table on p. 149, from which it will be seen that as regards expansion and fusibility, the advantage rests with copper, while in respect of weight it is only slightly heavier than zinc, bulk for bulk. The durability of a sheet of copper weighing 1 lb. per sq. foot is said to be equal to that of lead weighing 6 or 7 lbs., while its hardness renders it suitable for roofs over which there is likely to be traffic. It is laid in a somewhat similar manner to lead and zinc.

Sheets of iron, usually corrugated, are often employed for the roofs of outbuildings. They may be "galvanized" (*i.e.* coated with zinc) or painted. They are never used for the roofs of houses except for temporary purposes.

[1] Cement, however, does not act injuriously upon zinc, and the ill effects of iron are, for a time at least, prevented by galvanizing it.

TABLE III.

COMPARISON OF COPPER, LEAD, AND ZINC.

	Copper (Cu).	Lead (Pb).	Zinc (Zn).
Specific gravity, ...	8·85 to 8·94	11·37	6·86 to 7·21
Atomic weight, ...	63	206·4	65
Weight per sq. ft. $\frac{1}{10}$ in. thick, ...	4·6 lbs.	5·9 lbs.	3·7 lbs.
Melting-point in degrees Fahr., ...	2012°	633°	773°
Conductivity (silver being 100), ...	73·6	8·5	...
Linear expansion between 32° and 212° F.	·00171	·00285	·00297
Relative linear expansion,...	58	96	100
Weight per sq. ft. used for roofs,... ...	1 to $1\frac{1}{8}$ lbs.	6 to 8 lbs.	1 to $1\frac{1}{2}$ lbs.

A kind of flat roof which has been largely adopted in recent years, is really a floor, usually of **fire-resisting materials, covered with asphalt.** Roofs of this kind, if properly executed, possess several advantages over those already described: they are fire-resisting, undecaying, jointless, and durable, besides affording a surface pleasant to walk upon, and capable of withstanding a considerable amount of wear and tear. A common example of this kind of roof is given in fig. 80, where A A are steel joists, B concrete, C floated coat of cement and sand (1 to 2), D natural asphalt applied in two $\frac{3}{8}$-inch or $\frac{1}{2}$-inch layers, E asphalt fillet, and F asphalt skirting tucked into a joint in the parapet, the joint being first raked out to the depth of an inch, and pointed with cement mortar after the insertion of the asphalt. Such roofs should be laid to an inclination of not less than 1 in 40, and cesspools should be formed in the concrete and covered with asphalt, with lead pipes leading from the cesspools to the heads of the rain-water pipes. For roofs, artificial asphalts must not be used, as they may become soft in hot weather, and perhaps crack in cold weather or with the slightest inequality in the settlement of the building.

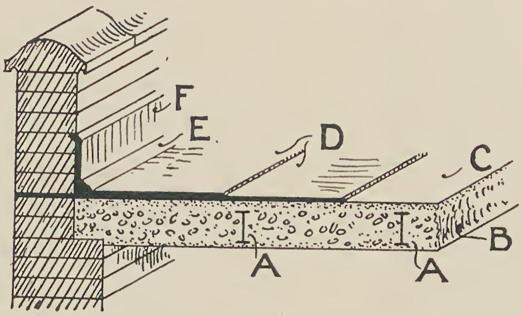


Fig. 80.—Flat Roof of Concrete and Asphalt.

Thin solid roofs, like that illustrated in fig. 80, are not an effectual protection against extremes of temperature, and may with advantage be ceiled beneath with wood or metal ceiling-joists, and wood or metal lathing covered with plaster. The air-space thus formed will increase the comfort of the room beneath.

Or instead of the solid concrete, one of the numerous kinds of floor may be used in which hollow lintels of brick or fire-clay extend between the joists. These lintels are keyed beneath to receive plaster.

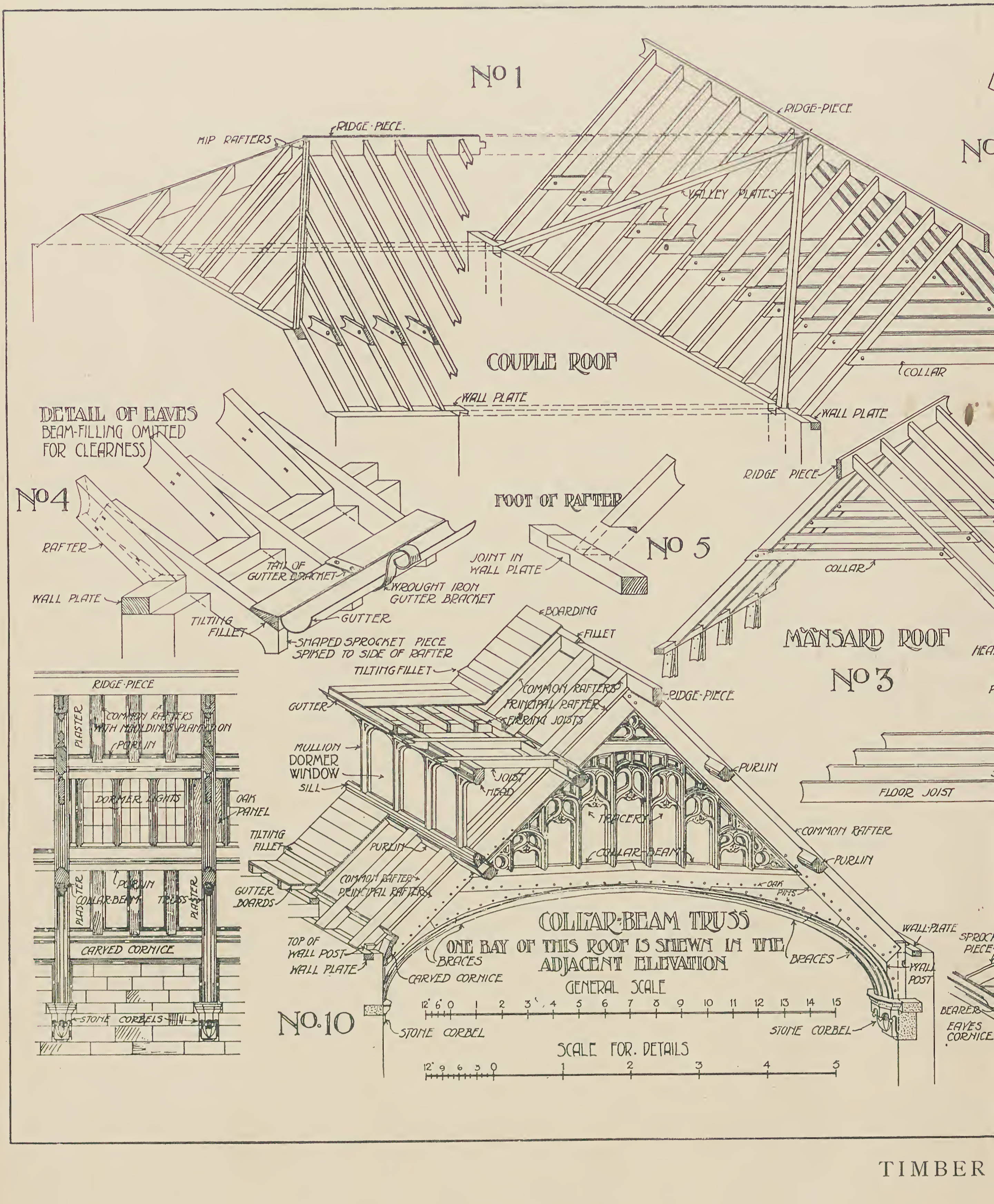
Occasionally an ordinary flat of **joists and boards** is formed and **covered with felt or canvas and asphalt.** The covering usually takes the form of alternate layers of a coarse fabric (often jute) and a bituminous composition, the whole being covered with fine clean gravel or spar to protect it from the weather. The verges are formed with zinc curbs perforated to allow the water to drain away. If the ceiling is plastered, through ventilation of the enclosed spaces must be obtained by means of air-bricks in the walls around the flat. Sometimes short fillets of wood are nailed along the top of the joists, but with spaces between the ends to form air-passages, and on these steel webbing or metal lathing is fixed and floated over with hair-mortar. When this is sufficiently hard, it is covered with a layer of concrete and a double layer of asphalt.

2. *PITCHED ROOFS.*

A simple collar or **couple roof** for bedrooms with ceilings partly flat and partly sloping is shown in No. 1, Plate IIIB. The timbers required are known as wall-plates, common rafters, collars, and ridge-piece.

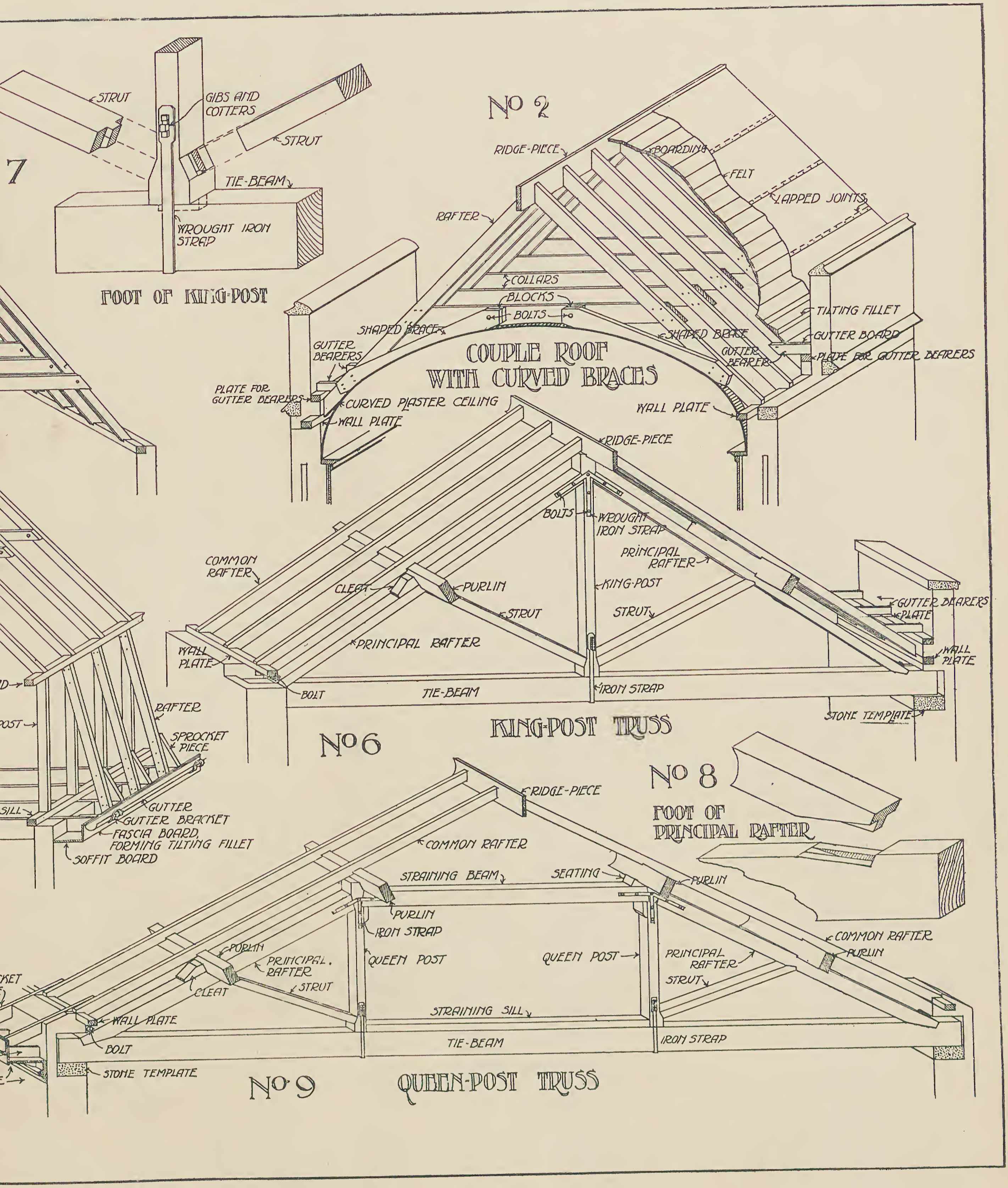
Wall-plates are usually 4½ inches by 3 inches, and are joined together by dovetail-halving as shown in No. 5, Plate III B, and strong nails; it is a good plan to tie the plates into the gable and cross walls by hoop-iron in order to prevent the plates from being pushed outwards by the rafters.

The common rafters are sometimes notched out to fit the upper and outer edge of the plates, but it is better to "birdsmouth" the ends to fit the upper and inner edge as shown in No. 5. In this case separate pieces, known as "sprockets" (shown in No. 4), are necessary to form any projecting eaves which may be required. The sprockets may be nailed or bolted to the back or (better) to the sides of the rafters. The upper ends of the rafters are usually splayed and nailed to the ridge-piece as shown in No. 1, but an alternative method, possessing certain advantages, is to halve the ends of each pair of rafters and then bolt them together, and along each side of the ridge to nail a batten or board (say, 6 inches by 1 inch) to prevent lateral movement of the rafters. If the whole roof is boarded, the special ridge-boards will not be required. For spans of 12 feet, the common rafters may be 4 inches in depth by 2 inches in breadth, and for an addition of 3 feet in span an extra depth of 1 inch and an extra breadth of ½ inch may



No 1
HIP RAFTERS
RIDGE-PIECE.
RIDGE-PIECE
VALLEY PLATES
COUPLE ROOF
COLLAR
WALL PLATE
WALL PLATE
DETAIL OF EAVES
BEAM-FILLING OMITTED
FOR CLEARNESS
No 4
RAFTER
WALL PLATE
TAIL OF
GUTTER BRACKET
WROUGHT IRON
GUTTER BRACKET
TILTING
FILLET
GUTTER
SHAPED SPROCKET PIECE
SPIKED TO SIDE OF RAFTER
FOOT OF RAFTER
JOINT IN
WALL PLATE
No 5
RIDGE PIECE
COLLAR
MANSARD ROOF
No 3
FLOOR JOIST
BOARDING
FILLET
TILTING FILLET
COMMON RAFTERS
PRINCIPAL RAFTER
RIDGE-PIECE
GUTTER
FIRRING JOISTS
MULLION
DORMER
WINDOW
SILL
JOIST
HEAD
PURLIN
TRACERY
COMMON RAFTER
TILTING
FILLET
PURLIN
COLLAR-BEAM
PURLIN
OAK
PINS
GUTTER
BOARDS
COMMON RAFTER
PRINCIPAL RAFTER
RIDGE-PIECE
PLASTER
COMMON RAFTERS
WITH MOULDINGS PLANTED ON
PURLIN
DORMER LIGHTS
OAK
PANEL
PLASTER
PURLIN
COLLAR-BEAM
TRUSS
PLASTER
CARVED CORNICE
STONE
CORBELS
COLLAR-BEAM TRUSS
ONE BAY OF THIS ROOF IS SHEWN IN THE
ADJACENT ELEVATION
TOP OF
WALL POST
WALL PLATE
BRACES
BRACES
CARVED CORNICE
WALL-PLATE
WALL
POST
GENERAL SCALE
12 6 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
No.10
STONE CORBEL
STONE CORBEL
SCALE FOR. DETAILS
12 9 6 3 0 1 2 3 4 5
BEARER
EAVES
CORNICE

TIMBER


7
STRUT
GIBS AND COTTERS
STRUT
TIE-BEAM
WROUGHT IRON STRAP
FOOT OF KING-POST
No 2
RIDGE-PIECE
BOARDING
FELT
LAPPED JOINTS
RAFTER
COLLARS
BLOCKS
BOLTS
TILTING FILLET
GUTTER BOARD
PLATE FOR GUTTER BEARERS
SHAPED BRACE
SHAPED BRACE
GUTTER BEARERS
GUTTER BEARERS
COUPLE ROOF WITH CURVED BRACES
PLATE FOR GUTTER BEARERS
CURVED PLASTER CEILING
WALL PLATE
WALL PLATE
RIDGE-PIECE
BOLTS
WROUGHT IRON STRAP
PRINCIPAL RAFTER
COMMON RAFTER
CLEAT
PURLIN
KING-POST
STRUT
STRUT
GUTTER BEARERS
PLATE
WALL PLATE
PRINCIPAL RAFTER
WALL PLATE
BOLT
TIE-BEAM
IRON STRAP
STONE TEMPLATE
KING-POST TRUSS
No 6
RAFTER
SPROCKET PIECE
GUTTER
GUTTER BRACKET
FASCIA BOARD, FORMING TILTING FILLET
SOFFIT BOARD
SILL
No 8
FOOT OF PRINCIPAL RAFTER
RIDGE-PIECE
COMMON RAFTER
STRAINING BEAM
SEATING
PURLIN
PURLIN
IRON STRAP
QUEEN POST
QUEEN POST
COMMON RAFTER
PURLIN
PURLIN
PRINCIPAL RAFTER
PRINCIPAL RAFTER
STRUT
STRUT
CLEAT
STRAINING SILL
WALL PLATE
TIE-BEAM
IRON STRAP
BOLT
STONE TEMPLATE
No 9
QUEEN-POST TRUSS

be given. Simple collar roofs of this kind are not suitable for spans much in excess of 15 feet.

The collars are usually of the same size as the rafters, but an extra depth of 1 or 2 inches is an improvement. Sometimes the sides of the rafters are cut out to form a dovetail recess, and the ends of the collars are halved and cut to a corresponding shape and fitted into the recesses, the joints being completed by bolts or strong nails. These joints are neat in appearance, but almost invariably the shrinkage of the wood nullifies any advantages which they may have had when first made, and in any case the timbers are weakened by the halving at the joints. The simple plan of bolting the collars to the rafters is on the whole the best. Instead of bolts, strong wrought-iron or mild-steel nails, about $\frac{3}{4}$ inch longer than the combined breadth of the two timbers to be joined, are sometimes driven through the timbers and "clenched",—that is to say, the projecting points of the nails are bent and hammered sideways into the wood. Four or five nails ought to be used at each joint.

The ridge-pieces are usually 2 inches broad, the depth being 3 or 4 inches more than the common rafters. A joint in the length of a ridge is usually formed by cutting and overlapping the ends and bolting them together.

Valleys are the internal angles formed by the intersection of two roofs as in No. 1. As a rule, a timber known as a "valley rafter" is fixed at the required slope along the line of intersection from the wall-plate to the ridge-piece, and the lower ends of the common rafters are cut and nailed to it. For a collar roof this method of construction is not the best. As the valley-rafters are deeper than the common rafters they extend below the sloping ceiling of the room and cut across it at unsightly angles; constructionally it is defective because some of the rafters cannot be tied together with collars. A better plan is to construct the main roof complete with ordinary rafters and collars as shown in No. 1, and to nail plates to the "backs" (or upper surfaces) of the rafters along the lines of the valleys; to these plates the lower ends of the short or "jack" rafters of the intersecting roof are fitted and nailed. This method requires more timber, but saves labour and gives a stronger roof.

Hips are the external angles formed by the intersection of two roof-slopes as shown in the left-hand part of No. 1. If the hip extends from the eaves to the ridge, it is a good plan to frame the lower end of each hip-rafter into a piece of timber fixed to the wall-plates across the angle formed by the two walls as shown in fig. 81; the outward thrust is thus distributed over a wider area of the walls. On the hipped end the common rafters have no collars, and a horizontal timber, known as a "purlin", is usually framed

between the hip-rafters to serve as an intermediate support for the common rafters. The hip-rafters are usually 3 or 4 inches deeper than the common rafters and about 1 inch more in breadth. As a rule the upper ends of the common rafters are simply bevelled to fit against the hip-rafters and are firmly nailed, but a better joint can be obtained by nailing a small batten along each side of the hip-rafter and by "forking" the upper ends of the common rafters on to this. It is a good plan to nail short wood struts to the sides of the hip-rafters between the common rafters to prevent the latter from slipping. The same method may be adopted in the case of valley rafters.

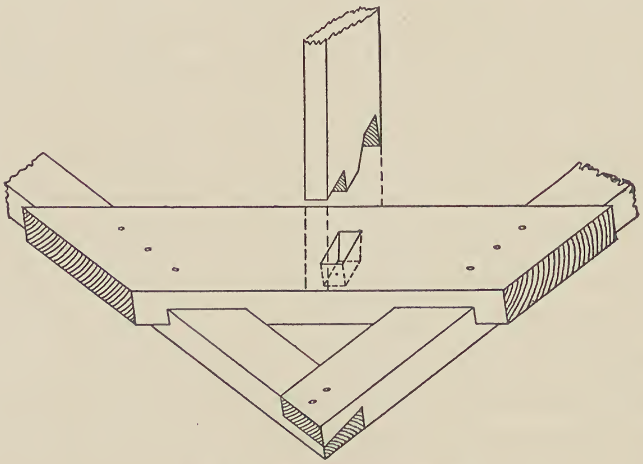


Fig. 81.—Joint at Foot of Hip-rafter.

A collar-roof with arched ceiling is shown in No. 2, Plate III B. The curved braces add to the strength of the roof. In this illustration parapet gutters are shown, and the roof is covered with boards and felt, on the top of which the slates or tiles are laid. Sometimes small fillets are laid from eaves to ridge on the felt, and nailed through to the rafters, and across the fillets tile-battens are nailed horizontally in the usual way.

A curb or **mansard roof** is one with two different slopes,—a steep slope in the lower part and an easier slope above. In No. 3, Plate III B, the lower portion has an inner timber framing in continuation of the walls below, and an outer framing of common rafters and horizontal sprockets, the rafters being firred out to a curve. The upper part is a simple collar or couple roof supported on the vertical framing. A lead apron is laid over the uppermost course of tiles in the lower roof, and is covered by the lowest course of tiles in the upper roof. The spaces between the timbers of the vertical framing are sometimes filled with bricks laid in mortar,—an operation known as "brick-nogging".

Purlins are horizontal timbers parallel to the wall-plates and ridge, and serve as intermediate supports for the common rafters, as shown in Nos. 6, 9, and 10. In the simplest roofs the ends of the purlins are supported by the gable and partition walls. Curb roofs are often simple roofs of this kind. The "scantlings" or sectional dimensions of purlins must be governed by the

span, the distance apart, and the weight of the roof (including the load due to wind-pressure). For a span of 10 feet, a distance apart of 5 feet, and an ordinary slated roof, a purlin 7 inches by 4 inches is sufficient. In the case of parsonage houses the Ecclesiastical Commissioners do not allow purlins to be used for a greater span than 10 feet. This is unnecessarily restrictive, but it is better to err on the safe side than to have a "sagging" roof. When the distance between the gable and partition walls is too great to be covered by purlins in one span, an intermediate support is required, and this is obtained by means of a "truss", as shown in Nos. 6, 9, and 10, Plate III B.

Roof-trusses are of infinite variety. When they are above the ceilings of the principal rooms, a simple *king-post truss* of unwrought timber (No. 6) is usually adopted. It consists of a tie-beam, a pair of principal rafters, a king-post and two struts, framed together and secured with iron straps and bolts in such a way that a rigid structure is obtained. Some details are given in Nos. 7 and 8. *A queen-post truss* (No. 9) has two queen-posts instead of one king-post, and is used for wide spans and for roofs with side slopes and a central flat. **A collar roof** (No. 10) has a collar-beam instead of a tie-beam. The example given was constructed of oak over a large dining-room, and includes wall-posts, arched braces, and tracery. In all cases the purlins are supported by the principal rafters of the truss.

Care must be taken that the ends of roof-timbers do not enter into smoke-flues; neglect of this may result in the destruction of the house by fire. The ribs (or purlins) and other woodwork must be amply strong enough; sagged roof-timbers mean broken slates and tiles, leaks, and insecurity. The space between the top of the wall and the upper side of the common rafters must be thoroughly filled with bricks and mortar, *before* the roof-boarding is laid or the slating begun; this is known as beam-filling.

The timber used in the construction of roofs in this country is usually that known as *red or yellow deal.* It is the timber of the Scotch Fir or Pine (*Pinus sylvestris*), and is obtained principally from the Baltic and White Sea ports. The classification varies in different ports, but as a rule five or six qualities are sold. The best or "firsts" quality is principally used for high-class joinery; it is also occasionally used for the best carpentry, but more commonly the "mixed" quality, consisting of "firsts" and "seconds", is used for such work. The planks and deals of "thirds" quality are, like the foregoing, sawn die-square, but contain more centres, knots, and sap. Inferior qualities have wany edges and a considerable proportion of sapwood (see fig. 82), and are often seriously weakened by shakes, large and dead knots, &c. As

sapwood quickly decays in the presence of moisture, architects often specify that all timber must be free from sap, but unfortunately all the yellow deal imported into this country contains more or less sapwood, and the only way of obtaining timber free from sap is to saw off the defective parts; thus, a plank 11 inches by 3 inches would have to be cut down to 9 inches by 3 inches (or less) in order to remove the sapwood. Timbers with wany edges, large or dead knots, and serious shakes ought not to be used.

Less durable and rather weaker timbers, which are often used for cheap roofs and floors, are Baltic *whitewood* (*Picea excelsa*) and American *spruce* (*Picea alba* and *P. nigra*). Much of this is sold as "unsorted", but in some ports three or more qualities are recognized.

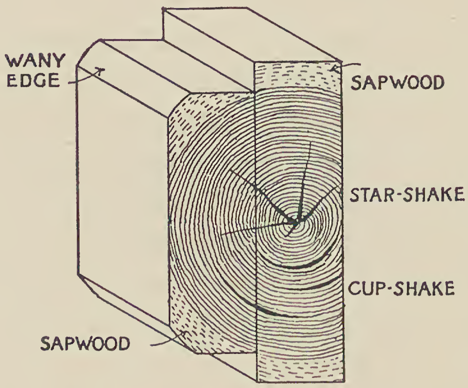


Fig. 82.—Some Defects in Timber.

For large scantlings American *pitch-pine* is often used. This is obtained from three or four different trees, the most important of which is the *Pinus palustris*. It is a strong and fairly heavy timber, and is durable in ordinary situations, but shrinks considerably in drying.

The only other timber in common use for roofs is *oak*. The variety most generally employed in this country is the European or common oak (*Quercus Robur*), much of it being imported from Baltic ports, but large quantities of the inferior American white oak (*Q. alba*) and of the Turkey oak (*Q. Cerris*) are also imported. The last variety comes chiefly from Austrian ports, and is used principally for flooring and joinery. Oak beams are difficult to dry, and for this reason shrinkage may go on for many years. A number of cracks in the sides of a beam show that the timber is still "green" at the heart, but cracks of this kind will gradually close as the timber becomes seasoned throughout. Unseasoned timber can also be detected by the blue colour which it gives to the carpenter's tools. Oak is the timber most commonly used in this country for the best open-timber roofs, but it is too costly for ordinary roofs.

Roof-coverings.—Pitched roofs are usually covered with slates or tiles, but sometimes thin flagstones (known locally as "gray slates"), thatch, copper, zinc, lead, wire-wove roofing, and sheet-iron (often corrugated and galvanized), are used. Temporary buildings may be covered with tarred felt on boards. Slates and tiles, however, are the chief roofing-materials.

Stone slates are thin slabs of stone, which have been split along the planes of bedding. Many of these slates are very "beddy", and may be cloven into sheets less than an eighth of an inch in thickness. Such slates should be rejected, as frost may split them. Stone slates are somewhat absorbent, and water does not pass very freely from them; roofs covered with them should therefore be of quicker pitch, say not less than 1 in $1\frac{3}{4}$, or $\frac{2}{7}$ of the span. These slates vary considerably in size and thickness, and must be carefully sorted into groups, each group containing slates of approximately uniform height and thickness. On account of their irregularity a greater lap is necessary than with clay slates; a 4-inch lap is commonly specified. The slates are laid on battens, being hung to them by one or two wood pegs driven through holes in the head of each slate, and the joints beneath are afterwards pointed with good hair-mortar, an operation known as pointing or torching.

Stone slates are heavy, somewhat absorbent but durable, and are warmer than clay slates, but they are not much used nowadays except for farm-buildings, and for repairs and additions to existing houses.

There are two principal districts in which **clay slates** are produced in these islands, namely, North Wales and the English Lake District; but other quarries are worked in Leicestershire, Devonshire, and Cornwall in England, Perthshire and Argyleshire in Scotland, and in Wicklow and Kilkenny in Ireland. Slate is one of the densest and strongest rocks, weighing from 170 to 180 lbs. per cubic foot, and having a crushing strength of 9 tons and upwards per square inch. Good slate is clean, non-absorbent, and practically unaffected by atmospheric agencies.

Welsh slates are of two geological formations, the *Cambrian* and the *Lower Silurian.* The former gives the well-known and excellent Penrhyn and Velinheli slates, and other slates shipped at Bangor and Carnarvon, while from the Lower Silurian formation are obtained the Ffestiniog slates (shipped at Portmadoc), the Llangollen slates, and others. The colour of Welsh slates varies considerably —red and purple Bangor, gray and purple Penryhn and Velinheli, green, blue, dark-blue, and even black. Some of the black slates are of wretched quality, and will break after a few years' exposure; many roofs covered with them have had to be stripped and covered with new slates. Perhaps it would be too broad a generalization to say that all dark or black slates are bad, but they are certainly not above suspicion. A good slate will ring clearly when struck, will not be friable at the edges or holes, will not splinter easily, will be free from dark veins, non-absorbent, straight, and of uniform thickness.

Welsh slates are almost invariably sold in regular sizes, the extremes being 36 inches × 24 inches and 10 inches × 5 inches. The smallest slates undoubtedly

make the prettiest roofs, as anyone who has observed the slated roofs and spires of the Belgian Ardennes will testify; but they are seldom used in this country, except for turrets, dormers, and summer-houses. The size most commonly used is 20 inches × 10 inches.

There are generally two or three qualities of Welsh slates: *firsts* are thin, straight, and of uniform thickness; *seconds* are thicker and less uniform; *thirds* are still more irregular. The smooth regularity of a roof covered with *firsts* Welsh slates is far from pleasing; such slates, moreover, are so thin that they are easily broken by anyone walking over them. *Seconds* slates, from which the most irregular have been discarded, make stronger and more pleasing work.

The slate quarries of the English Lake District have during recent years largely increased their output. These slates—which are commonly known as **Westmoreland slates,** although they may be quarried in that county or in Lancashire or Cumberland — are stronger and thicker than ordinary Welsh slates, more durable and of better appearance. Some of them, as the Elterwater, Tilberthwaite, Coniston, and Langdale slates, are of various shades of green, while others, such as those obtained near Ulverston, are blue. They are more expensive than Welsh slates, but are worth the extra cost; the green slates are much in favour now for the roofs of buildings constructed of red brick or terra-cotta, the contrast of colour being decidedly pleasing. For stone buildings also the green roof is welcome; a stone building with a blue roof has a cold, dull appearance.

Westmoreland slates are usually sold by the ton, and not, like Welsh slates, by the "thousand". And the slates in each consignment vary in size, and must be sorted (as already explained in the case of stone slates) before being laid. The extreme dimensions and "qualities" of Westmoreland slates are not uniform throughout the district, but the following table will be useful as an example; it refers to the Elterwater green slates.

Slates must be so laid that wind and rain cannot pass directly between them. To attain this object, the slates in alternate courses must be laid to break joint as shown in figs. 76 and 83, and the lower part or tail of the slates in any course above the two lowest must overlap the head of the course next but one below it. This overlapping is clearly shown in figs. 77 and 83, and is called the "lap" to which the slates are laid. For steep roofs, and for low-pitched roofs where parsimony prevails, the lap is often no more than 2 inches; indeed jerry-builders reduce it to 1 or $1\frac{1}{2}$ inches. For good work, however, the lap should be 3 or $3\frac{1}{2}$ inches, and in exposed situations a 4-inch lap is often necessary.

TABLE IV.

ELTERWATER GREEN SLATES.

	Quality.	Price per ton on rail.	Computed to cover, with 3 in. lap
			Sq. Yards.
L	Best slate, 28 in. to 12 in. long, proportional widths, ...	105/-	about 28
	Best slate, 16 in. to 12 in. long, proportional widths, ...	100/-	„ 29
	Coarse grained, 28 in. to 12 in. long	90/-	„ 24
C	Second slate, 24 in. to 12 in. long, various widths, ...	70/-	„ 20
	(Recommended for colour, which is equal to best.)		
T	Thirds, 26 in. to 10 in. long, various widths, ...	40/-	„ 14
	(A strong slate suitable for mill work, farm out-buildings, &c.)		
P	Best Peggies, 12 in. to 9 in. long, ...	80/-	„ 29
	(Equal to first quality in texture and colour.)		
	Best Peggies, coarse grained, 12 in. to 9 in. long, ...	70/-	„ 25
	Second Peggies, 10 in. to 6 in. long, ...	45/-	„ 24
	Unselected, 10 in. to 6 in. long, ...	40/-	„ 22

Before the slates are laid they must be **holed for nailing**. Each slate, unless it is of very small size, must have two holes, which may be either in the upper corners of the slate as shown at A A, or near the middle of the sides as shown at B B. Objection is sometimes taken to the latter position on the grounds that moisture may be driven through the nail-holes, and that the nails may be injured by the moisture. Neither ground of objection has much importance, and as the slates are certainly more securely held when nailed in the middle, and less liable to be broken and stripped by the wind, side-holing is becoming more common. The exact distance of the holes from the tail (or lower edge) of the slate is important.

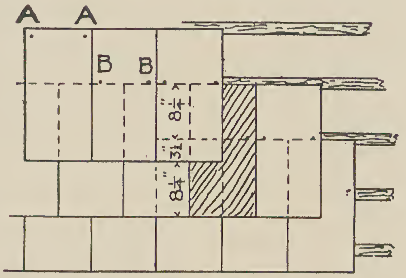


Fig. 83.—Plan of Slated Roof.

Slaters are apt to take it as the measure of the lap; thus, if slates 20 inches long are specified to be laid to a lap of $3\frac{1}{2}$ inches, the slater will, unless especially cautioned, drill the holes $11\frac{3}{4}$ inches from the tail, leaving $8\frac{1}{4}$ inches from the holes to the head; this, the slaters say, gives a lap of $3\frac{1}{2}$ inches, and a glance at the shaded slate and the dimensions in fig. 83 might seem to bear out their view. Two little details, however, are ignored by the slater, the *first* being that slates vary a little in size, and the *second* that nails must be entirely *above* the head of the slate below, and not exactly on the line of the head. These two little details are really of great importance, for, in order

to make sure that the nails in one course will be quite clear of the heads of the *longest* slates in the course below, the slater allows from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch from the head of the average slate to the holes in the slate above. I have known 20-inch slates holed as described, and yet laid with a lap of less than 2 inches, a lap quite insufficient to render a low-pitched roof water-tight in an exposed situation, unless the slates are laid on boards and felt. Slates should therefore always be holed to show at least one inch more lap than is specified. The distance of the nail-holes from the tail of the slate may be found by the following simple rule, the several dimensions being stated in inches:—

$$\frac{\text{Length of slate} + \text{lap} + 1}{2} = \text{distance of nail-holes from tail.}$$

Slates are laid either **on battens or on boarding**; sometimes on battens nailed to boarding. For common work, battens alone (or, as they are often called, "laths") are used, as they are least costly. The laths are nailed to the rafters, and if these are not more than 12 or 13 inches *apart*, the laths need not be more than about $1\frac{1}{2}$ inch $\times \frac{3}{4}$ inch or $1\frac{3}{4}$ inch $\times \frac{7}{8}$ inch. The laths must be spaced according to the size of the slates and the required lap:—

$$\frac{\text{Length of slates} - \text{lap}}{2} = \text{distance of laths from centre to centre.}$$

Thus, for slates 20 inches long, specified to be laid to a lap of $3\frac{1}{2}$ inches, the distance from centre to centre of the laths must be

$$\frac{20 - 3\frac{1}{2}}{2} = 8\frac{1}{4} \text{ inches.}$$

Slates laid on laths must be pointed or torched underneath with haired mortar.

The house, however, will be drier and of more uniform temperature if **boarding covered with felt or waterproof paper** be used instead of laths. The boards may be $\frac{3}{4}$ or 1 inch thick, tongued and grooved to prevent warping, and nailed to the rafters either horizontally or diagonally. As snow and rain will drive through the joints of the slates, it is necessary to cover the boards with some impervious material which will protect them from the moisture and from consequent decay. The material may be either *Willesden waterproof paper* (one-ply or two-ply), or some kind of *felt*. Felt is more frequently used. Of this material there are two principal varieties—*tarred* felts (which are usually known as "sarking" or "roofing" felts), and felts prepared with resin instead of tar, and known as "*inodorous*" felts. The tarred felts are tougher and more durable, and less liable to injury by vermin, and the smell is scarcely perceptible

when the roof is complete. The thicker qualities of each kind should be selected. Felt is supplied in rolls usually 32 inches wide, and is laid in horizontal courses, each new course overlapping that below it about $1\frac{1}{2}$ or 2 inches, all being secured to the boarding with nails.

Sometimes the slates are nailed directly to the sheathing, or to horizontal **laths** nailed to it, but a better plan consists in nailing thereon laths or battens running from eaves to ridge either directly or diagonally, and in nailing to these the usual horizontal slating laths. The space thus formed between the sheathing and the slates keeps the roof warmer, and helps to preserve the wood and slates from decay. The slater proceeds by nailing a **tilting-fillet** along the eaves, as shown at D in figs. 76 and 77. This is necessary, in order to give the slates that slight variation from the slope of the roof which is required to allow them to bed close to each other throughout their length. If the tilting-screed or its equivalent were omitted, the tail of each slate would stand clear of the slate below, and the wind and rain would find entrance, and might, indeed, strip off the slates.

The first course of slates must be shorter than the ordinary slates by the amount of the **gauge** to which the slating is to be laid. The gauge of slating as of tiling is the length of slate (or tile) exposed to view in each course. For 20-inch slates laid to a lap of $3\frac{1}{2}$ inches, the gauge, as shown in fig. 77, is $8\frac{1}{4}$ inches. The subsequent courses need no explanation.

All slates must be secured with **nails,** which may be $1\frac{1}{2}$ or 2 inches long, according to the thickness of the slates, and may be of copper, zinc, or "composition" (a mixture of copper, zinc, and tin). Iron nails, whether galvanized or not, should not be allowed, as they soon rust. Copper nails are used for the best work, but composition nails are also durable.

Roofing-tiles are of several kinds, the most generally used being the "plain" (or "plane") tile, similar to those described in Chapter III. of this Section, pp. 119–120. These are either simple oblongs or shaped on the lower edge, and are hung to wood laths by nibs formed on the tiles, or (in exposed situations) by copper or galvanized iron nails about $2\frac{3}{4}$ inches long. The usual colour is deep red, but other colours can be obtained—strawberry, blue, brindled, &c.—and semi-vitrified or glazed tiles are also made, and have the advantages of durability and imperviousness. Hips and valleys are formed by special tiles, as shown in fig. 84, and wide tiles are inserted in the alternate courses of gables in order that the tiles may break joint. Roof-tiles are laid to gauges of 4, $3\frac{1}{2}$, or 3 inches, 54, 62, and 72 tiles respectively being required in every square yard. Tiles are heavier than slates, and as a rule more absorbent and more

expensive; on the other hand, they are warmer. The Ruabon and Broseley tiles enjoy a good reputation.

A novel method of laying plain tiles on concrete or mortar, instead of on boards and felt, was introduced some years ago by Mr. Ralph Nevill, and has stood the test of experience. The first operation consists in nailing the plaster-laths to the underside of the common rafters, lest, if it were done afterwards, the concrete might suffer by the jarring. Single fir laths are then fixed with lath-hooks to the upper side of the rafters, and an eaves-lath or tilting-fillet is nailed

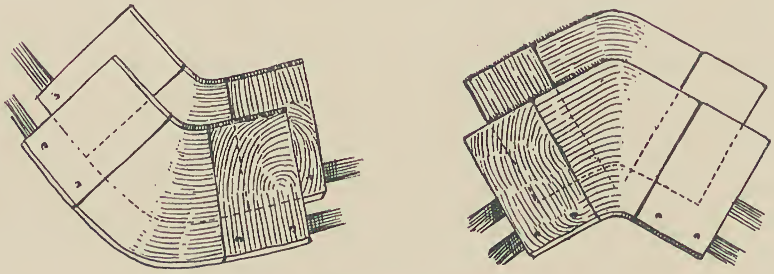


Fig. 84.—Hip-tiles and Valley-tiles.

along the eaves. Copper nails $2\frac{1}{2}$ inches long are then driven into the upper side of the rafters at distances of about 4 inches, and left projecting about an inch to furnish a key for the concrete, which is subsequently deposited to a thickness of about $1\frac{1}{4}$ inch. This concrete consists of *one* part of clean sharp sand, *three* parts of finely-sifted clean ashes or coke-breeze, and *one* part of a mixture of selenitic lime and Portland cement (3 to 1). The concrete must be laid in long strips, beginning at the eaves, and laying only so much as can be covered with tiles before it has become too hard. The surface must be trowelled fairly smooth, particular care being paid to the hips and valleys. After the concrete has been deposited for about 6 or 8 hours in the daytime, or about 10 or 12 at night, it will be ready to receive the tiles. The tiles may be gauged by means of chalk lines snapt on the concrete, and are fixed by pressing two pins to each tile into the still moist concrete; "the thickness of concrete against chimneys, barge-boards, &c., should be slightly increased, so as to tilt the tiling, and throw off the water. As there will be no foothold on the roof, and all the tiles will be worked over, it will be necessary to sling a cradle over the ridge, resting on well-stuffed bags. To avoid returning over the tiles, it is important that the ridge should be fixed as the tiling is done."[1]

Of **special roofing-tiles** there are numerous varieties. Pan-tiles are only

[1] *The Builder*, Dec. 9 1896.

used for farm-buildings and cheap work, but several other varieties are suitable for good houses, such as the Broomhall tile, Major's, Taylor's, and others. Concrete roof-tiles have also been made, and a special diamond-shaped sort is now being introduced into this country after having achieved some measure of success abroad; its appearance, however, is most inartistic.

"**Ridging**" is the name given to the materials used for covering the ridges of roofs. Blue and red ridge-tiles are now most generally used on account of their cheapness, but stone and slate ridgings are also used; these should all be bedded and jointed with cement-mortar. Fig. 85 shows a $2\frac{1}{2}$-inch wood roll with $1\frac{1}{2}$-inch neck, and a sheet of lead 24 inches wide dressed over the roll and down the slates about 7 inches on each side, and nailed to the wood roll with round-headed nails. The neck allows the lead to be dressed a little under the roll, but additional security can be obtained by sheet-copper tacks nailed to the wood under the lead and with the ends turned over the lead wings. The end joints between two sheets of lead are simple laps of about 6 inches.

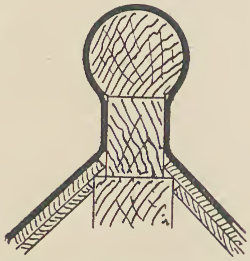


Fig. 85.—Ridging formed with Wood Roll and Lead.

Hips may be formed in tiled roofs by special tiles as already explained, and in slated roofs by ʌ-shaped tiles or other material, or by wood rolls and lead, exactly as ridges. Frequently, however, the hips of slated roofs are formed by carefully cutting the slates to the requisite angle (known as "close bevel cutting"), and inserting at the angle in each course of slates a thin lead soaker ($2\frac{1}{2}$ or 3 lbs. per sq. foot) cut to the proper shape and bent to the angle of the hip; this is the neatest method of forming hips.

Valleys in slated roofs are formed with 5 lbs. or 6 lbs. sheet-lead, about 18 inches wide, laid (with laps of from 3 to 6 inches at all joints) on boarding, or with soakers as described for hips. In tiled roofs, curved valley-tiles may be used.

The **dead weight of roofs** varies considerably, but the table on p. 162 is approximately correct.

Eaves-troughs or **gutters** are still sometimes made of wood, but as a rule cast-iron is now preferred. Lighter gutters of galvanized wrought-iron and of zinc are also made, but are not as durable as cast-iron. Eaves-troughs should be securely fixed, either by being screwed to a fascia nailed to the end of the rafters, or by wrought-iron hangers nailed to the upper side of the rafters or boarding, and passing under the trough. Hangers are sometimes of ornamental appearance. In addition to screws or hangers, the gutters may be supported on stonework or on iron brackets. Stone cornices are sometimes hollowed and lined with lead to form eaves-gutters.

Table V.

WEIGHT OF ROOFS.

Material.	Weight per sq. yd. in cwt.
Timber framing, ...	·3 to ·5
Boarding 1-inch thick,...	·2 „ ·25
Copper,...	·1 „ ·12
Zinc, ...	·12 „ ·14
Lead, ...	·6 „ ·7
Welsh slates, ...	·6 „ ·9
Westmoreland slates, ...	·8 „ 1·2
Plain tiles, ...	1·2 „ 1·6
Concrete and asphalt, ...	4 „ 6

Instead of lead gutters, like those shown in figs. 74, 77, and 79, **cast-iron gutters** of the requisite section and $\frac{1}{4}$, $\frac{3}{8}$, or $\frac{1}{2}$ inch thick, are sometimes used. The joints may be either lap-joints, or butt-joints with flanges bolted together; the joints must be carefully made with a mixture of red and white lead, or with a mixture of iron-borings, sulphur, and sal-ammoniac. Iron gutters of this kind condense moisture, and are somewhat apt to leak (for a time at least), besides being damaged by rusting. In certain circumstances, however, they can be used with advantage.

In this connection a few words may be said about **rain-water pipes.** They are now seldom made of wood, although here and there a prejudice lingers in favour of this material. Most frequently cast-iron pipes are used; they are made circular and rectangular, the former being the stronger and more durable. Rain-water pipes should be fixed so as to stand about 2 inches from the wall in order that they can be painted all round, and that in case of a leak the wall will not be saturated with the water. This object may be effected by wood blocks, or (better) by using a special pipe such as Law's, or the Perfection, as shown at P in Plate III. Solid-drawn lead pipes have recently come into use. They are expensive and easily bulged, but on the other hand they do not need painting, and do not crack as easily as iron pipes; nor do they rust. The thickness of the metal should be from $\frac{3}{32}$ to $\frac{1}{8}$ of an inch, *i.e.* from 6 to 8 lbs. per sq. foot, and the pipes must be secured to the walls by lead tacks not more than 3 feet 6 inches apart. It is a mistake to use small rain-water pipes; the smallest size allowable is 2 inches in diameter, and this should only be fixed to the roofs of bay-windows and other minor roofs. Pipes 3, $3\frac{1}{2}$, and 4 inches in diameter are better.

Rain-water pipes should not on any account be connected directly with the sewage-drains, but should discharge over or into trapped gullies. The position of rain-water pipes should be so arranged that they help to flush the drains; *e.g.* a rain-water pipe near a sink-waste or a soil-pipe greatly assists in keeping the drains clean. They may also with advantage be connected with an automatic flushing-tank at the head of the principal drain. If the sewage is conducted to a cesspool or a private purification-plant, a separate system of rain-water drains is necessary.

CHAPTER VIII.

FLOORS.

Impervious ground-floors resting on the solid ground have certain advantages over the ordinary joisted and boarded floors raised a foot or so above the ground or ground-layer. They are more secure against rot, and afford no space for dirt and vermin to lodge, besides effecting, in many cases, a saving in excavation, foundations, and walls.

They may be formed of **concrete** on the top of the asphalt layer, as shown in figs. 42 and 43, and in Plate II. This concrete need not be more than $1\frac{1}{2}$ or 2 inches thick, save in those exceptional cases where considerable pressure of water has to be resisted. In places where appearance is no object, or where the traffic is light, the concrete may consist of one part of Portland cement and two parts of pea-gravel, well mixed and trowelled or floated to a smooth surface. The less sand that is used the better, as it renders the concrete less durable, and therefore causes more dust. For better work, hard limestone, marble, granite, syenite, spar, alabaster, glass, pottery, &c., crushed and passed through a screen with half-inch meshes, may be used instead of gravel. A mixture of these materials gives variety to the appearance of the floor, and sometimes additional variety is given by pressing somewhat larger pieces into the concrete here and there as soon as it is laid. When the cement has set properly, the floor is ground down with stone rubbers, sand, and water, until a clean polished surface is obtained. Frequently colouring matter—Venetian red, ultramarine, &c.—is added in mixing the ingredients, but a more permanent colour effect is obtained by the use of coloured aggregates, chiefly marble and granite; borders and centres are often finished in different colours. These polished concrete floors are often known as **concrete mosaic,** but the more

general name now is **terrazzo.** When properly laid, they are extremely durable and clean, and have a pleasing appearance. They are suitable for corridors, pantries, &c., and also for sculleries, water-closets, bath-rooms, wash-kitchens, and other places where much water is used, but for living-rooms they have the demerit of coldness.

Concrete mosaic must not be confounded with **Roman mosaic,** each tessera of wnich is carefully laid by hand in the exact position required by the design. This is a more expensive kind of floor, but affords scope for ornamental effects impossible in the other. The cubes are usually of marble or fine pottery, the latter being known as *ceramic mosaic* and the former as *marble mosaic.* A bed of cement-mortar floated to a perfectly level surface must be prepared to receive the mosaic.

Tiles of various kinds are also used for floor-surfaces, and must be laid in quick-setting cement on a level bed of cement-mortar. Sometimes thin slabs of **marble,** or of other hard stones, are laid in patterns in cement-mortar. All these floors are as a rule clean and durable, but are often noisy and cold.

Sometimes an ordinary smooth finishing coat of cement-mortar is given to the concrete, and on it **kamptulicon, linoleum,** or **cork carpet** is glued. A more durable covering is now made from wood fibre, cork dust, and other materials mixed with an indurating liquid, and laid *in situ* to a thickness of about $\frac{3}{8}$ inch. Various colours can be used, and the material can be oiled or wax-polished. Among the floors of this kind the **Stonwod, Terrano,** and **Acop** may be mentioned.

For living-rooms, however, a wood surface is usually preferred on account of its warmth. This can be obtained by using either **wood-block flooring,** or **parquetry.** The latter is as a rule the more ornamental and perfect flooring.

The ordinary **wood-block flooring** consists of blocks of wood from 1 to 2 or even 3 inches thick, and usually 9 inches by 3 inches on the face, grooved along the sides as shown in fig. 86, and laid in molten pitch or bituminous composition on a perfectly level and dry surface of cement-mortar or natural asphalt. The pitch should be well squeezed into the grooves of the blocks, and the whole of the floor when laid should be well planed, so as to bring all the blocks to one smooth and uniform surface. The pitch in which the blocks are embedded is itself damp-proof, but it not infrequently happens that cracks and holes are left in it, through which moisture rises to the wood, causing decay. For perfect safety the ground-layer should be covered entirely with an asphalt damp-course as already described, on which the wood-blocks may be laid in molten pitch in

Fig. 86.—Ordinary Wood-block Floor.

the usual way. Blocks with faulty grooves, or badly laid, or of unseasoned wood (especially pitch-pine), frequently wear loose. Hence special systems of flooring have been devised, in which the blocks are firmly secured to each other or to the bed by means of tenons, dowels, screws, &c. These systems undoubtedly have their advantages, and should be adopted where the additional outlay can be afforded.

Various kinds of wood may be used for block floors, the cheapest being yellow or red deal; other woods are pitch-pine, oak, teak, walnut, jarrah, mahogany, and also beech, birch, and the dark-red Indian wood known as padouk. Red-deal blocks ought never to be less than $1\frac{1}{2}$ inch thick; sometimes blocks 2 inches and more in thickness are used. The harder woods are usually laid in blocks 1 inch or $1\frac{1}{4}$ inch thick, the thicker being the more secure and durable, and of course more expensive. The peculiar odour of teak must not be forgotten when the selection of wood is being made; the odour—or rather the oil which yields the odour—apparently renders the wood less liable to the attacks of insects, but it is to many persons objectionable, and teak cannot therefore always be adopted. Oak is the wood most largely used in good work, walnut, mahogany, &c., being occasionally introduced in bands and patterns to add to the effect.

Hardwood floors are often **wax-polished,** and sometimes **French-polished;** these processes add to the brightness of the floors, and at the same time render them cleaner, as all the joints and pores are stopped by the wax and shellac.

A variety of wood-block flooring consists of the use of longer pieces of wood, "secret-nailed" to fixing-blocks embedded in the concrete below, or to fillets of coke-breeze concrete. Special fixing-blocks for the purpose, composed of a kind of concrete capable of holding nails, can be obtained in 12-inch lengths, and of dovetailed section. Wood fixing-blocks must not be used, at any rate on ground-floors. The damp-course of asphalt (natural or artificial) must not be omitted from the ground-layer, or the wood above may rot. The joints of the boards may be as shown in fig. 87, where joint No. 3 is that used in the patent "Pavodilos" flooring. These boards may be polished as ordinary block floors.

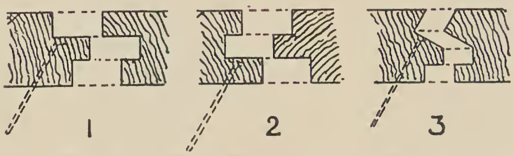


Fig. 87.—Sections of "Secret-nailed" Wood-blocks.

Parquetry is the most elaborate and the most sanitary kind of wood flooring. It consists of small pieces of hardwoods of various kinds and colours, arranged in patterns (often of considerable intricacy), and carefully dowelled, glued, and

screwed together. Sometimes the parquetry is one inch thick, each piece of wood being the full thickness; it is then known as "solid" parquetry. "Plated" parquetry consists of a hardwood surface about $\frac{1}{4}$ inch thick, fixed to a properly-framed deal backing, or, as in Turpin's patent, to two or three thin laminations or layers of hardwood well glued together; in Mackenzie's system a metal backing is used. Panels of plated parquetry, containing about 100 square feet, can be supplied by the makers ready for fixing. Parquetry, like wood blocks, must not be laid on ground-layers unless an asphalt damp-course has been spread to receive it. Flagged floors may be covered with asphalt and finished with parquetry $\frac{1}{4}$ inch thick. The surface of parquetry may be wax-polished or French-polished, the latter process being a little more expensive.

Floors resting on the solid ground were at one time formed chiefly with **flags, tile quarries, or bricks,** without any preparation beneath except a layer of ashes. This method of construction is seldom adopted now in towns, as it is cold and damp, and, indeed, in most cases it would be in contravention of the by-laws. A layer of concrete 6 inches in thickness is usually demanded, and this, in the case of tiles and bricks, should be floated level with cement-mortar (1 to 2). The joints of flags, tiles, and bricks should be run with neat cement-grout.

Hitherto we have been dealing with floors resting on the solid ground or on the concrete ground-layer. Frequently, however, floors constructed of **wood joists and boards** are desired for ground-floor rooms; sections of such floors have already been given on pages 82 and 90, and in Plate III. The ends of the joists should not be built into the walls, but should rest on wall-plates laid on set-offs formed in the walls, and should always be above the damp-course. Sleeper-walls are often built at intervals under such floors in order to lessen the bearing of the joists, and consequently their scantling, but such walls must be of the "honeycomb" kind, as solid walls interfere with the circulation of air under the floor, and may therefore induce decay in the wood. The boards are usually 1 or $1\frac{1}{4}$ inch thick, and tongued and grooved at the edges to prevent warping, and to guard against crevices extending through the full thickness of the boards in case of shrinkage. Good yellow (or as it is often called, "red") deal is well adapted for both joists and boards, but white deal and spruce are often used in cheaper buildings. The rings in red deal should be clearly marked and of bright colour, and the wood should be free from sap, cracks, large knots, and especially from any trace of fungus or decay. For buildings of the best class, and especially for ball-rooms, secret-nailed oak (or other hardwood) boards are used, either alone or on the top of deal boards. and may be left in the natural state or polished at will.

Dry rot is the great danger to be feared in wood ground-floors. This is a kind of decay caused by the development of a fungus, the *Merulius lacrymans*, four conditions favouring the growth, namely—stagnant air, dampness, warmth, and absence of light or sunshine. The first two conditions are those with which the architect is most concerned, and these he can generally avoid by adequate ventilation and by impervious ground-layers and walls. The ventilation, however, must be adequate; particularly must every corner of the room have its own ventilator. It is not sufficient if air-grates or ventilating damp-courses are inserted on one side only of a room, or on two sides at right angles to each other; ventilation must be ensured on at least two sides opposite to each other, so that a through current of air may be induced. To secure this, it will often be necessary to form air-drains with bricks or drain-pipes under adjacent solid floors, or to construct vertical air-flues in the walls, gathered perhaps to the smoke-flues above. The air-grates below the floor-level must be carefully protected outside, so that they may not be inadvertently blocked. Many cases of dry rot have been developed in consequence of gardeners having covered the air-grates which the architect had carefully provided. Care must be taken in selecting the wood for floors, as in many cases traces of white fungoid growth can be seen before the wood is fixed; a consignment containing wood of this sort should be condemned in bulk. Chips of wood left under floors are a source of danger, and impervious floor-coverings, such as linoleum, by preventing the passage of air, increase the risk of rot.

Wet rot is not as insidious or as frequent as dry rot, and the quantity of moisture necessary for its appearance will never be present in a building carried out with reasonable care and skill.

The upper floors of ordinary houses are usually formed with **wood joists covered above with floor-boards** and beneath with wood laths and plaster. It is better for the ends of the joists to rest on set-offs formed in the walls, as shown at A in fig. 52, page 117, but where this cannot be done the joists must touch the walls only on their lower surfaces, so that a clear space is left around the ends for circulation of air. This reduces the risk of rot. As a further precaution the ends of the joists may be coated with some preservative, such as Stockholm tar, carbolineum, and solignum. Special joist-boxes of cast-iron or stoneware can be obtained for building into walls to receive the ends of joists, and are more to be depended upon than a method which leaves so much to the skill and care of the bricklayer.

Floor-joists are usually fixed 15 inches from centre to centre, but some regulations require them to be not more than 12 inches *apart*, so that joists

2 inches in breadth will be 14 inches from centre to centre. The joists must be "trimmed" around hearths, flues, stair-wells, &c. In fig. 88 two methods of trimming around a chimney breast and hearths are shown. In the lower the joists are parallel to the chimney breast, and in this case one trimming

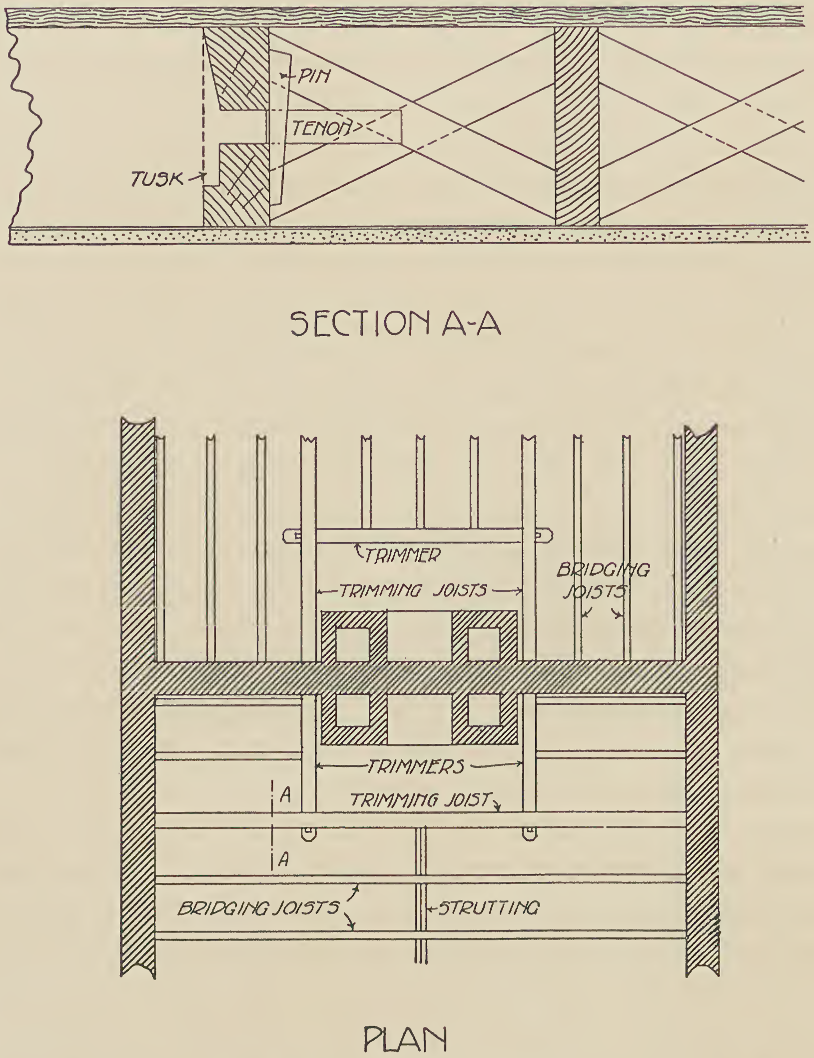


Fig. 88.—Floor-joists trimmed for Hearths.

joist and two trimmers are required. In the upper the joists are at right angles to the breast, and two trimming joists and one trimmer are required. The trimmers and trimming joists are usually 1 inch broader than the ordinary or bridging joists, but if the opening is large greater strength is necessary. The trimmers are tenoned through the trimming joists and secured with keys,

and the bridging joists are tenoned through the trimmers. To stiffen the floor, herring-bone strutting is usually fixed between the joists, one row for spans less than 8 feet, two rows for spans between 8 and 12 feet, and so on. A load over one joist is by means of the strutting transmitted to some of the other joists, and the risk of cracked ceilings is reduced.

The strength of floor-joists and other bearing timbers, supported at the ends, may be calculated from the simple formula—

$$W = \frac{4Cbd^2}{3l}$$

where W = breaking weight in pounds distributed equally over the length,[1] l = length of clear span in inches, b = breadth of timber in inches, d = depth of timber in inches, and C = coefficient, which varies according to the kind and quality of the timber. For good yellow deal the value of C is about 5000, for white deal or spruce 4000, for pitch-pine 7000, for American white oak 6000, for European oak 9000, for teak 11,000. The strength of timber varies very widely, knots being the chief source of weakness. But even when all scantlings containing large knots have been eliminated,—and this ought always to be done,—the strength of the remaining pieces is far from uniform. The load is also uncertain, much of it in the case of floors being "live" or moving load, which may stress the timber twice as much as the same amount of "dead" load, or even more. For these and other reasons a factor of safety must be employed, and for timber this is usually 8 or 10; in other words, to obtain the safe load, the breaking weight obtained by the formula must be divided by 8 or 10. In calculating the load on house-floors it is customary to assume that an allowance of $\frac{3}{4}$ to 1 cwt. per square foot is ample for all ordinary live and dead loads.

A simple rule for floor-joists of yellow deal, fixed 15 inches from centre to centre, may be deduced from the formula. The transverse strength of timber varies directly as the breadth and square of the depth, and inversely as the length, or as $\frac{bd^2}{l}$. As the load is usually a multiple of the length, it need not be separately considered. The following simple rule is therefore sufficient for all ordinary house floors. Multiply the breadth in inches by the square of the depth in inches and divide by the length of clear span in feet, and if the quotient exceeds 8 the joist may be used for common work; if it exceeds 12, the joist is suitable for good work. Briefly, then, $\frac{bd^2}{L} = 8$ to 12.

[1] If the load is concentrated at the centre of the span, the breaking weight obtained by the formula must be divided by 2.

Transposing this, we obtain—

$$1.\ d^2 = \frac{8\text{ L}}{b}, \text{ and } b = \frac{8\text{ L}}{d^2}, \text{ for common work.}$$

$$2.\ d^2 = \frac{12\text{ L}}{b}, \text{ and } b = \frac{12\text{ L}}{d^2}, \text{ for good work.}$$

As an example, what must be the depth of a joist 2 inches broad for a span of 12 feet?

$$1.\ d^2 = \frac{8 \times 12}{2} = 48, \text{ and } d = 7 \text{ inches for common work.}$$

$$2.\ d^2 = \frac{12 \times 12}{2} = 72, \text{ and } d = 8\tfrac{1}{2} \text{ (say 9) inches for good work.}$$

Again, what must be the breadth of a joist 7 inches deep for a span of 12 feet for good work?

$$b = \frac{12 \times 12}{7 \times 7} = \frac{144}{49} = 3 \text{ inches.}$$

The rule is applicable only to joists with a depth at least twice as great as the breadth, and in this connection it may be pointed out that, if a stiff floor is required, the depth of a joist ought not to be much less than one-twentieth of the span.

Some building regulations specify the sizes of floor-joists to be used for different spans, and add that other sizes may be used if of equivalent strength. Comparisons can be made by multiplying the breadth by the square of the depth in each case. Thus, if a joist 8 inches in depth by $2\frac{1}{2}$ inches in breadth is specified for a certain span, $bd^2 = 2\frac{1}{2} \times 8 \times 8 = 160$. The same (or a little more) strength will be shown by a 9-inches-by-2-inches joist, as $bd^2 = 2 \times 9 \times 9 = 162$.

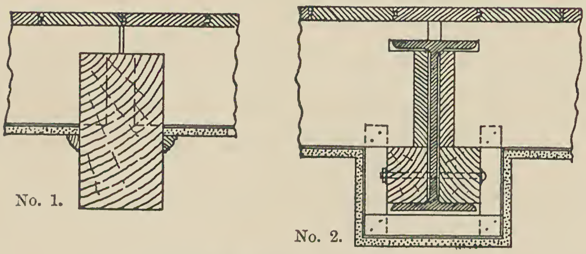


Fig. 89.—Beams in Wood Floors.

Beams to support the joists of large floors may be of timber or rolled steel, the latter being now usually preferred. When wood beams are used, the joists are as a rule fitted into notches cut into the upper parts of the beams (No. 1, fig. 89). The common method of connection to rolled steel joists is shown in No. 2. The lower flange of the steel joist is bracketed around and covered with wood casing or lath-and-plaster. Where resistance to fire is desired, the steel must be protected with terra-cotta blocks or reinforced concrete (fig. 92).

To deaden sound, a counter floor is sometimes formed between the joists with rough boards nailed to fillets which have previously been nailed to the sides of the joists; the space above the counter-floor is then filled with sawdust or lime-pugging (both dangerous in respect of rot), or with silicate-cotton. Sometimes silicate-cotton slabs are nailed under the joists and fillets nailed below, to which the lath-and-plaster ceiling is attached in the ordinary way; or silicate-cotton slabs, plastered on one side and strengthened by wire-netting embedded in the mass, are screwed to the joists to form the rough ceiling. Plate III. shows a floor with ceiling-joists spiked under the floor-joists at right angles to them, thus allowing circulation of air between the timbers, but the best method of preventing the transmission of sound through a wood floor is to fix ceiling-joists parallel to the floor-joists and about 1 inch lower, so that the plastered ceiling is quite independent of the floor above.

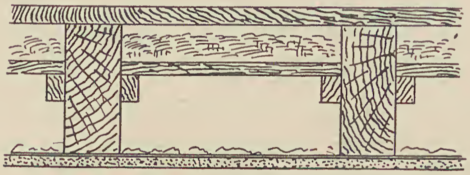


Fig. 90.—Wood Floor and Counterfloor with Lath-and-plaster Ceiling.

Wood floors, however, of the kinds described are undoubtedly combustible, besides containing numerous inaccessible places for the accumulation of fine dust and vermin. They may with advantage be superseded by **solid wood floors,** formed with ordinary floor-joists fixed close together and spiked to each other, and either planed level on the top or covered with thin floor-boards. Such a floor is practically fire-proof, and has most of the advantages of ordinary wood floors without the disadvantages; there is, however, considerable danger of decay unless the wood is of good quality and properly seasoned.

Parquet flooring is frequently laid on the top of ordinary wood floors, and may be either fixed or removable. Thin oak boards are also used, secret-nailed as a rule, and generally polished.

Fire-resisting floors of many kinds have been largely used in recent years, but chiefly in business-premises and public buildings. In houses, somewhat strange to say, the attention has not been given to the subject which its importance warrants. As I have already pointed out, fire-resisting construction is a matter of *materials* and also of their *arrangement.* If we avoid combustible materials, such as wood, a step has been taken in the right direction, but care must also be exercised that the incombustible materials used in their stead are at least moderately fire-resisting. Undoubtedly good clay, burnt at a high temperature (whether in the form of bricks or terra-cotta), furnishes one of the best fire-resisting materials. Concrete, composed of one part of Portland cement and not more than four parts of a *suitable* aggregate (such as broken

bricks, properly-burnt clay, and furnace-clinker), is of considerable merit, but bad concrete, especially with stone aggregates, is most treacherous in a fire, and may collapse entirely at an early stage. Iron and steel also, although not combustible, are not by any means fire-*proof*, but bend and twist under great heat, and, if not protected, may give way and so lead to the destruction of the building.

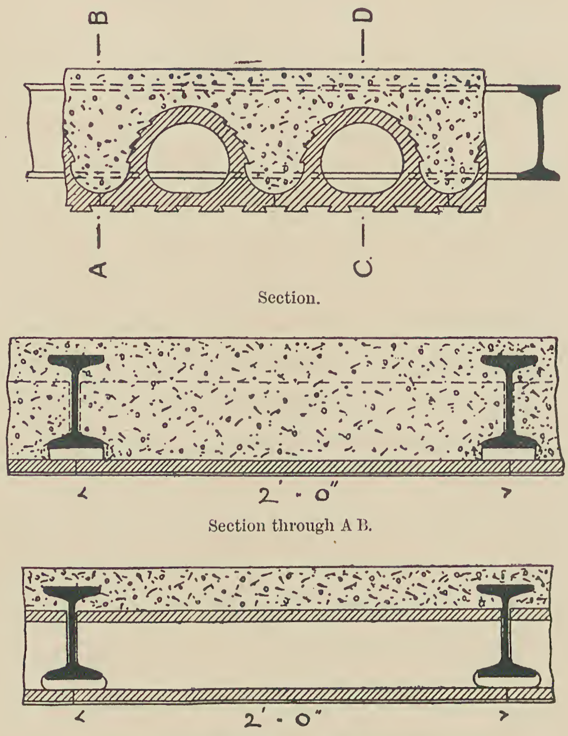
From the facts just stated, two rules may be laid down for guidance in designing fire-resisting floors:—

1. Concrete alone is dangerous, and must therefore be protected, or prevented from total or extensive collapse.

2. Iron and steel must be entirely surrounded by an adequate thickness of fire-proof material, or in some other way protected from the action of fire.

Rule 1 throws out of court the large-span floors of concrete alone, but not concrete floors containing iron or steel joists or tees at short distances, or a meshwork of rods or bars or expanded metal, with the metal protected beneath and above by fine concrete, plaster, &c.

Rule 2, however, is more stringent, and demands greater protection of the metal from fire than is attained in ordinary fire-resisting floors. Several patented floors, however, have been designed in accordance with it. In **Fawcett's floor,** illustrated in fig. 91, the protection of the metal is obtained by means of terra-cotta tubular lintels, the ends of which are grooved to clip the flanges of the joists in such a manner that the joists are entirely protected beneath by the flat bottoms of the lintels; they are protected above by coke-breeze concrete, of which the bulk of the floor is formed. The lintels are grooved beneath to afford a good key for plaster, this furnishing an additional protection to the metal. It will be noticed that a continuous circulation of air can be maintained through the lintels and beneath the joists. The joists are of steel, fixed 2 feet from centre to centre.



Section.

Section through A B.

Section through C D

Fig. 91.—Fawcett's Fire-proof Floor.

A floor on very similar lines is now made with tubular lintels of re-inforced concrete instead of terra-cotta, and with re-inforced concrete joists instead of steel.

In **the "Kleine" floor** (fig. 92) special bricks, either solid or hollow, and measuring 10 inches by 6 inches by 4 or 5 inches, are laid end to end on temporary wood centring. The deeper bricks are used for large spans and for floors to carry heavy loads. Between the rows of bricks light iron tension-bars, supported at the ends on walls or steel joists, are bedded in good cement-mortar, and all the joints are filled with similar mortar. Above the bricks coke-breeze or other concrete is deposited to the required thickness, and the

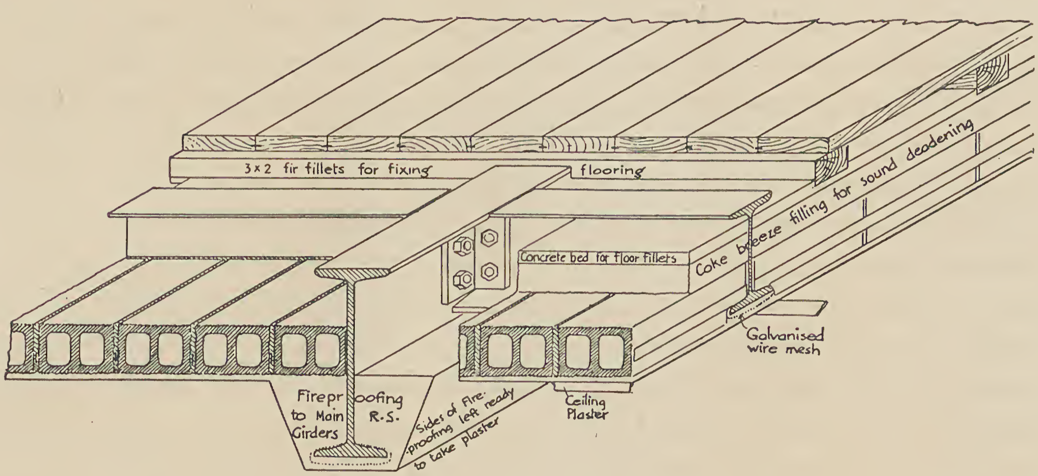


Fig. 92.—The "Kleine" Patent Fire-resisting Floor.

surface is rendered with cement-mortar, on which wood blocks, Stonwod, or other solid flooring can be laid. For flats and other buildings where sound-resisting floors are desired, the method of construction shown in the illustration is suitable; 3-inch-by-2-inch fir fillets are laid on the cement, and floor-boards are nailed to them. Electric-light and bell wires, gas-pipes, &c., can be "run" in the spaces between the wood fillets, screwed boards being fixed for access. Floors of this kind up to a span of 20 feet can be constructed without steel joists. If a plastered ceiling is required, bricks grooved on the lower side are used. An illustration of the "Kleine" system of constructing fire-resisting stairs is given in No. 2, fig. 96, page 185.

The illustration shows a method of protecting the lower flanges of steel joists by means of galvanized wire netting and fine concrete, and the upper flanges may of course be protected in the same way.

Other floors of a somewhat similar kind, such as the "Frazzi", are now made with long tubular lintels of fine terra-cotta.

In **Banks's floor** the metal is protected simply by an air-space, and a fire-resisting ceiling consisting of "helical" metal lathing and plaster. It is

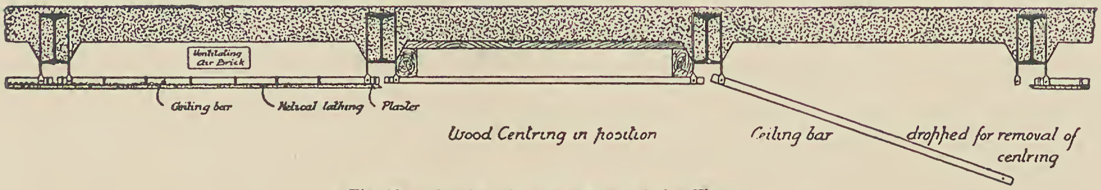


Fig. 92 A.—Section of Banks's Fire-resisting Floor.

illustrated in fig. 92A, and has the merits of simplicity and economy, while it also affords opportunity for ventilation and is not as noisy as a solid floor.

In many upper rooms, where much water is used,—as in bath-rooms, cistern-rooms, water-closets, housemaids' closets, lavatories, &c.,—a floor of other material than wood is desirable, not so much for its fire-resisting qualities as for its imperviousness and freedom from decay. In such cases, a **simple slab of concrete** may be used for spans up to about 8 or 10 feet. Thinner floors of good concrete are more trustworthy than thick floors of inferior concrete; it is therefore better to use concrete composed of *one* part cement and not more than *three* parts of some hard aggregate (say granite or syenite), broken to pass through a screen with meshes $1\frac{1}{4}$ inch square. A thickness of 4 inches I have found to be sufficient for spans up to 6 feet, and 6 inches will suffice for 10-feet spans. For work executed by unskilled men in the ordinary way, a considerable margin of safety must always be allowed, but flat granolithic floors 16 feet by 9 feet, and only 3 inches thick, have been constructed by specialists, while arched floors of the same material, 21 feet 6 inches span and $29\frac{1}{4}$ inches thick at the springing and 3 inches thick at the crown (the rise of the arch being only $26\frac{1}{4}$ inches), are said to have been loaded with 8 cwts. per square foot without injury. In some of these special floors, however, iron or steel rods were embedded in the concrete.

Combined **steel and concrete floors** are now largely used, the steel being in the form of expanded metal, rods, bars, tees, or joists. When the strength is dependent upon the resistance of the two materials in conjunction, the combination is known as "re-inforced concrete". In America, square twisted rods are often employed, the twist preventing the rods being drawn through the concrete when subjected to the usual stress. Steel tees, flat side down, may be used to increase the strength of concrete floors. When the metal is in the

form of tension members only, it is particularly important that the wood staging should be perfectly rigid; otherwise it will sag under the weight of the wet concrete. As a general rule, however, the metal in concrete floors is in the form of joists, fixed from 2 to 4 feet apart, and varying in size according to the spacing, the span, and the load. Joists strong enough to bear the weight of the concrete and of the load on the floor are generally used; this is somewhat wasteful of metal, but the resulting floor will generally, notwithstanding this, be cheaper than any of the special floors. The following table gives the sizes and weights of steel joists which may be used in floors of this description in houses, the joists being fixed 2 feet from centre to centre, and the concrete being from 1 to 2 inches more in depth than the joists:—

Table VI.

STEEL JOISTS IN CONCRETE FLOORS.

Size of Joists.	Weight per ft.	Maximum Span.
in. in.	lbs.	feet.
3 × $1\frac{1}{2}$	4	6
4 × $1\frac{3}{4}$	5	8
$4\frac{3}{4}$ × $1\frac{3}{4}$	$6\frac{1}{2}$	10
4 × 3	$9\frac{1}{2}$	12
5 × 3	11	14
6 × 3	12	15

The wood staging for concrete floors should be fixed at least half an inch below the steel joists, and the space between the boarding and the joists should be thoroughly filled with cement-mortar (1 to 2) immediately before the concrete is deposited. The staging should remain in position as long as possible; where joists are not used, the period should be not less than six weeks. Concrete floors are strongest when laid over the walls and subsequently built upon, but where this cannot be done, corbel-courses or chases must be formed to receive them. Newly-deposited concrete must be protected from traffic, drought, and frost. Coke-breeze is a common aggregate for floor-concrete, on account of its lightness; it is, however, weak, and may with advantage be superseded by broken brick.

The surfaces of concrete upper floors may be finished in one of the ways described in the former part of this chapter, or with wood fillets to which ordinary floor-boards are nailed (fig. 92). Sometimes coke-breeze fillets or composition blocks are used to receive the boarding, as wood fillets are somewhat apt to decay. The ceilings may be finished with Keene's or other cement.

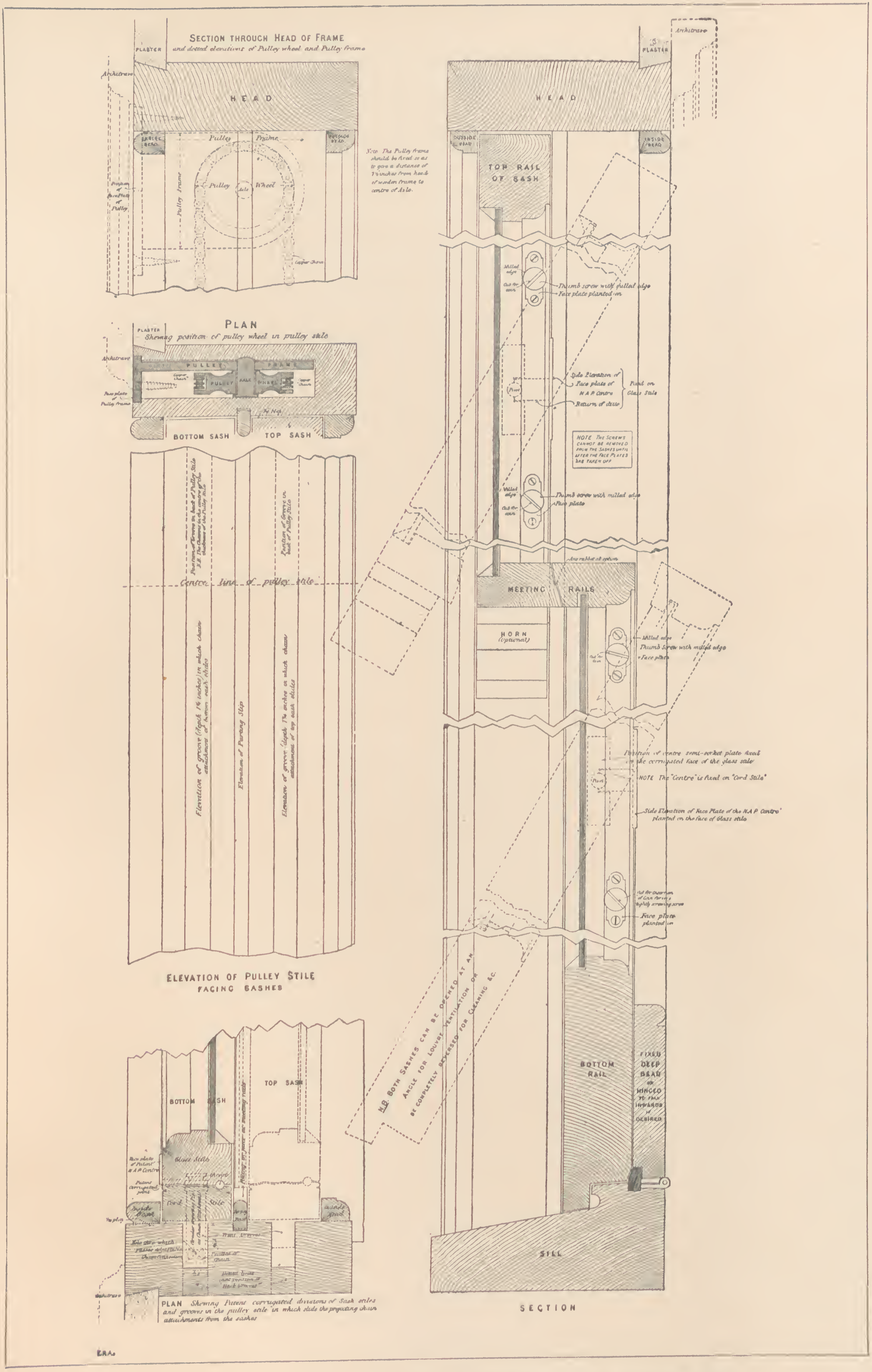
CHAPTER IX.

WINDOWS, DOORS, SKIRTINGS, AND STAIRS.

1. *WINDOWS.*

The **windows** of a house have a very important influence on its comfort and healthfulness. To some of the general principles of window design, attention has already been drawn in Chapter I. A few words must now be said on the practical details of their construction. The insertion of glass into grooves in the stonework of windows is now nearly obsolete, and deservedly so, on account of the lack of ventilation, and the number of cracked sheets of glass caused by the rigid framework, and the trouble of replacing them. It is usual nowadays to provide a wood or metal frame to receive the glass. Windows are of two principal classes, *sash-windows* and *casements*, and each class has its peculiar advantages and disadvantages.

Sash-windows are peculiarly British in their origin and development, being seldom seen abroad. They are especially suitable for openings of considerable size, but look clumsy when used in small mullioned windows. They are convenient, easily made weather-proof (although somewhat apt to rattle in strong wind), and may be readily used for ventilation. On the other hand, they are somewhat intricate and apt to get out of order, and the outside of the glass is difficult to clean. Indeed so great is the trouble of cleaning, and so many accidents have occurred to persons standing on the window-sills for this purpose, that it is no wonder that inventors have turned their attention to the subject. Numerous patents have been taken out for windows so arranged that the sashes can be reversed, and therefore cleaned from the inside of the room. In Glasgow, the building-regulations require all new sashes to be reversible, and other towns will doubtless follow the example before long. Reversible sashes may be hung in the ordinary way with cords and weights, or may be hung over pulleys so as to balance each other, thus dispensing with weights. Details of the National Accident Prevention Company's "weightless" window are given in Plate IV. In such windows the bottom sash necessarily rises when the top sash is lowered, and as it is frequently desirable that air should be admitted to the room only at the meeting-rails and top of the window, it becomes necessary to give a very deep bottom rail to the bottom sash and to fix a correspondingly deep face-board inside, as shown in the section. A similar arrangement is, however, advantageous in ordinary sashes, as air can then be admitted at the



THE N.A.P. WEIGHTLESS REVERSIBLE WINDOW.

meeting-rails only when desired, where it acquires an upward current; the risk of draughts is thereby reduced.

Into the details of ordinary sash-windows it is not necessary to enter. One or two points, however, may be mentioned. The sills should be of oak or teak, and weathered and throated on the top; in the section in Plate IV. only one throating is shown, but another, immediately under the outer face of the bottom rail, is often formed, as in Plate V. The sills should be bedded in white-lead, and the joint is all the more weather-tight if a galvanized iron weather-tongue (about 1 inch by $\frac{1}{4}$ inch) is let into grooves cut in the under side of the wood sill and the upper side of the stone sill, and bedded in white-lead. The meeting-rails should be rebated at their junction, one method being shown in the illustration. If the vertical parting-beads between the sashes are of teak, there will be less likelihood of them swelling and of the sashes sticking fast. Red (yellow) deal is the wood most frequently used for the sashes themselves and the other parts of the frames, but in high-class buildings oak, mahogany, and other woods are preferred. Weights may be of iron or lead, the latter being more expensive but less bulky. Sash-lines may be of hemp, flax, steel ribbon, or zinc, copper, or steel chains; hemp is coarse and cheap; superfine flax is a very good material, but for heavy sashes the steel and copper lines are the best. Cheap pulleys are wholly of iron; better ones are brass-bushed, others have brass faces and wheels, and some have roller bearings. Sash-fasteners are of infinite variety, the simple screw-fastener being as safe as any, and having the merit of drawing the sashes tightly together and preventing rattling to some extent.

A combined sash-and-casement window is illustrated in Plate V. This is simple and weather-proof, and allows the glass to be cleaned inside the room. It is little more expensive than an ordinary sash-window, and combines with it the merits of a French casement. In the illustration the lower sash is much larger than the upper, and consists really of two casements hung to stiles to which the weights are attached, and which slide up and down in the ordinary grooves. The upper sash is simply an ordinary sliding sash; this can, however, be fitted with folding casements if desired. The fittings required for a combined window of this kind are somewhat numerous. Besides the usual pulleys, lines, and weights, there ought to be a bolt at the foot of each casement and a sash-fastener at the top; sunk handles for raising the lower sash may with advantage be fixed in the bottom rail, and a loop in the top rail of the upper sash for lowering this by means of a stick and hook. A short but strong bolt to unite the meeting-stiles of the casements allows the two casements to be raised together, but the same object may be attained by carrying a rail across the head

of the casements. The latter method, however, is somewhat clumsy, the window becoming practically an ordinary sash-window with casements hung in the sashes.

Casement-windows are almost universal on the Continent. Indeed, large casement-windows reaching to the floor are commonly known as "French windows". They are, however, now frequently used in this country, being better adapted than sash-windows for the small mullioned windows now in vogue. They consist of a casement hung (generally with butt hinges) in a fixed solid frame. The casement may open inward, which has the merit of allowing the glass to be easily cleaned on both sides, but adds to the risk of rain being driven into the room and of the window being blown open, and interferes with the blinds and curtains; or it may open outward, when these conditions will be reversed. Fig. 93 shows the jamb and sill of an inward-opening wood casement, and fig. 93A those of one opening outward. The sills should be of oak, weathered and throated, and provided with a weather-tongue. "French casements" are usually hung folding,

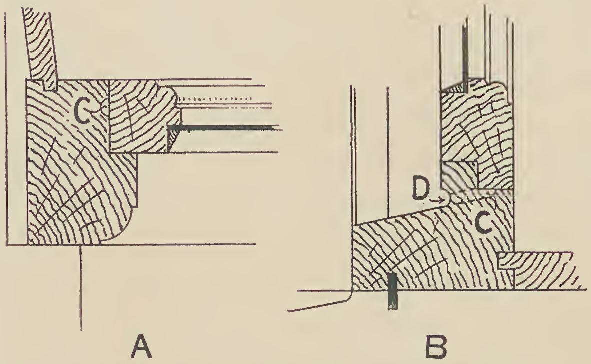


Fig. 93.—Wood Casement and Frame, the casement to open inward.

A, horizontal section of jamb and stile; B, vertical section of sill and bottom rail; CC, grooves to collect water driven along joints between casement and frame; D, holes to convey water from grooves to sill outside.

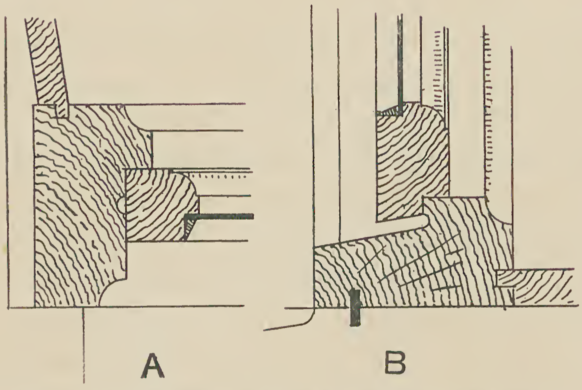
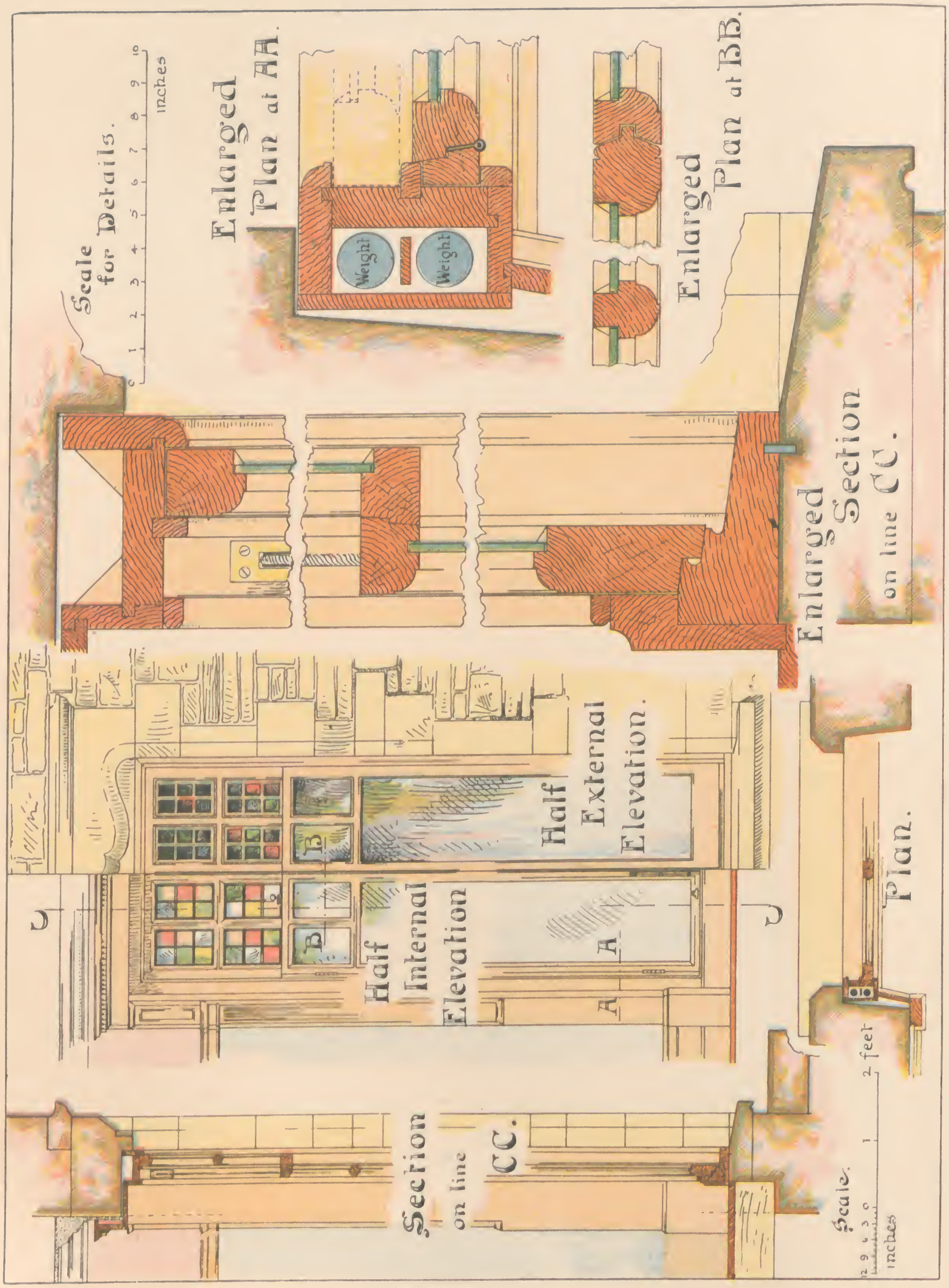


Fig. 93A.—Wood Casement and Frame, the casement to open outward.

A, horizontal section of jamb and stile; B, vertical section of sill and bottom rail.

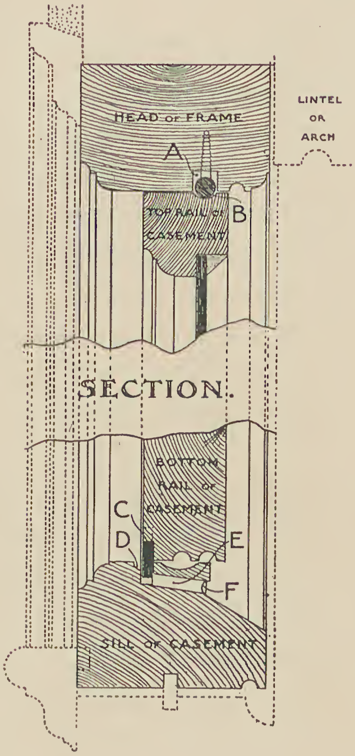
Fig. 93B.—Meeting-stiles of French Casement.

and the meeting-stiles may be shaped in a great many ways; a good water-tight arrangement is given in fig. 93 B, and another was given in Plate V. Fig. 93 C contains details (one-fourth full size) of the N.A.P. wood casement, which is so designed that it will open either inward or outward on a double-knuckle hinge shown at C. Special precautions are taken to prevent the



DETAILS OF COMBINED SASH-AND-CASEMENT WINDOW.

ingress of rain; these are clearly explained by the drawings. The purpose of the invention is to facilitate the cleansing of the glass, while at the same time



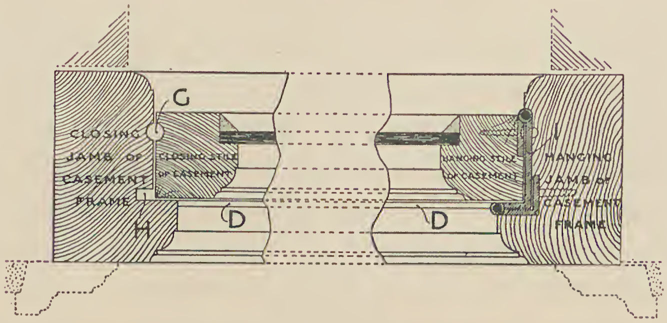


Fig. 93C.—The N.A.P. Window Casement, inward and outward opening. (One-fourth of full size.)

A, groove to receive brass weather-rod; B, brass rod, which automatically rises from the position shown (travelling up the necks of two screws), as the casement is swung either inwards or outwards; C, position of water-bar when the casement is in ordinary use; D, condensation-channel; E, two outlets (from D) at $\frac{1}{3}$ the width of casement; F, outlet (from weather-channel on top of sill) in centre of casement; G, throat to receive rain-water, but single or double rebates may be substituted if desired; H, groove (for a height equal to the width of the casement) to receive the water-bar when in the vertical position which it occupies while the casement is passed through the frame; I, patent N.A.P. double-knuckle hinge.

retaining some of the advantages of the outward-opening casement.

Metal casements are now frequently used, wrought-iron being most common but gun-metal being adopted in the very best work. They can be obtained in a great variety of sections, from simple L-iron to complicated arrangements like that shown in fig. 93D. The sill, jambs, and head of the opening must be specially prepared to suit the section of casement-frame which may be adopted. Metal casements are expensive, but they do not take up much room, and they are durable if regularly painted. Gun-metal, of course, does not require painting.

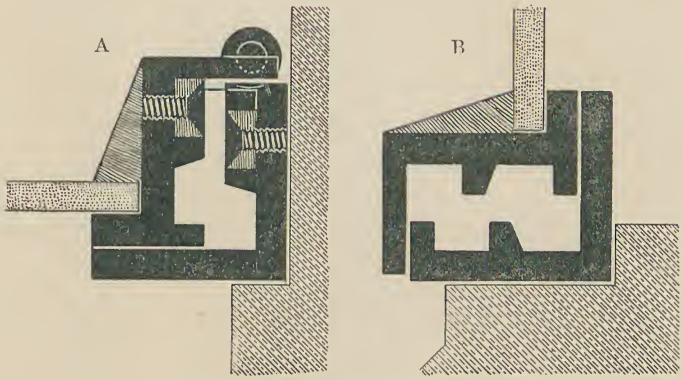


Fig. 93D.—Wrought-iron Casement and Frame.

A, horizontal section of casement and jamb; B, vertical section of casement and sill.

Mention has already been made of the coldness of windows in winter, and of the improvement in this respect which may be gained by means of **double windows,** or **double panes of glass** with a small air-space between. Both devices reduce the sound transmitted through the windows, and this is certainly a great blessing in towns. When double windows are used, the outer window may be a sash-window, and the inner one a casement (generally hung folding and opening inward). Double panes are, however, a better protection against changes of temperature: Péclet's tests showed that, counting the loss of heat through a single sheet of glass as 1, the loss through two sheets 2·8 inches apart is ·6, 2 inches apart ·55, and ·8 of an inch apart only ·47. The construction of windows to receive double sheets of glass presents little or no difficulty; the wood must simply be rebated on both sides, and the outer sheet may be secured with putty in the usual way, while the inner may be kept in position by a small bead sprigged to the framing.

Glass is a very important part of a window. It is a comprehensive term, including sheet-glass, rough and polished plate-glass, patent rolled plate-glass in a great variety of tints and patterns, ground and obscured glass, enamelled sheet- and plate-glass, &c. Polished plate-glass is undoubtedly the best for most purposes, the most common thickness for ordinary house-windows being $\frac{1}{4}$-inch. Sheet-glass is of various qualities, and is sorted into thicknesses, usually known as 15-ounce, 21-ounce, 26-ounce, 32-ounce, and 36-ounce. The kind of glass to be used in any window or borrowed light will depend on the purpose it has to serve. If the window is for prospect and abundance of light, then sheet-glass or (better) plate-glass must be used. If, however, the prospect is obnoxious, some other kind of glass is desirable, such as patent rolled plate or leaded lights. It must not be forgotten, however, that every process which renders glass less clear to the eye, renders it also less transparent to light. Sir Douglas Galton gives the following results of experiments:—

Polished British plate-glass, $\frac{1}{4}$-inch thick,	intercepted	13	per cent	of the light.
36-ounce sheet-glass[1]	,,	22	,,	,,
Cast plate-glass, $\frac{1}{4}$-inch thick,	,,	30	,,	,,
Rolled plate-glass,[2] 4 corrugations in an inch,	,,	53	,,	,,

These figures may be supplemented by others[3] dealing with coloured glass as well as with plain:—

[1] This would be about $\frac{1}{6}$-inch thick. G. L. S.
[2] This would be about $\frac{1}{8}$-inch thick. G. L. S.
[3] From *Praktische Gewerbehygiene*, edited by Dr. H. Albrecht. Berlin, 1896.

Ordinary window glass	intercepted	4	per cent	of the light.
Double and crown glass	,,	9–13	,,	,,
Plate-glass	,,	6–10	,,	,,
Ground glass	,,	30–66	,,	,,
Green and red glass	,,	80–90	,,	,,
Orange glass	,,	34	,,	,,
Opal glass	,,	35–75	,,	,,

Doubtless the green and red colours were very strong. The "ordinary window glass" must have been extremely thin; it would have been better if the thickness of the glass had been given in each case.

2. *DOORS.*

Doors in houses are not generally of elaborate or peculiar construction, and do not therefore call for much notice. Two examples are given in fig. 94.

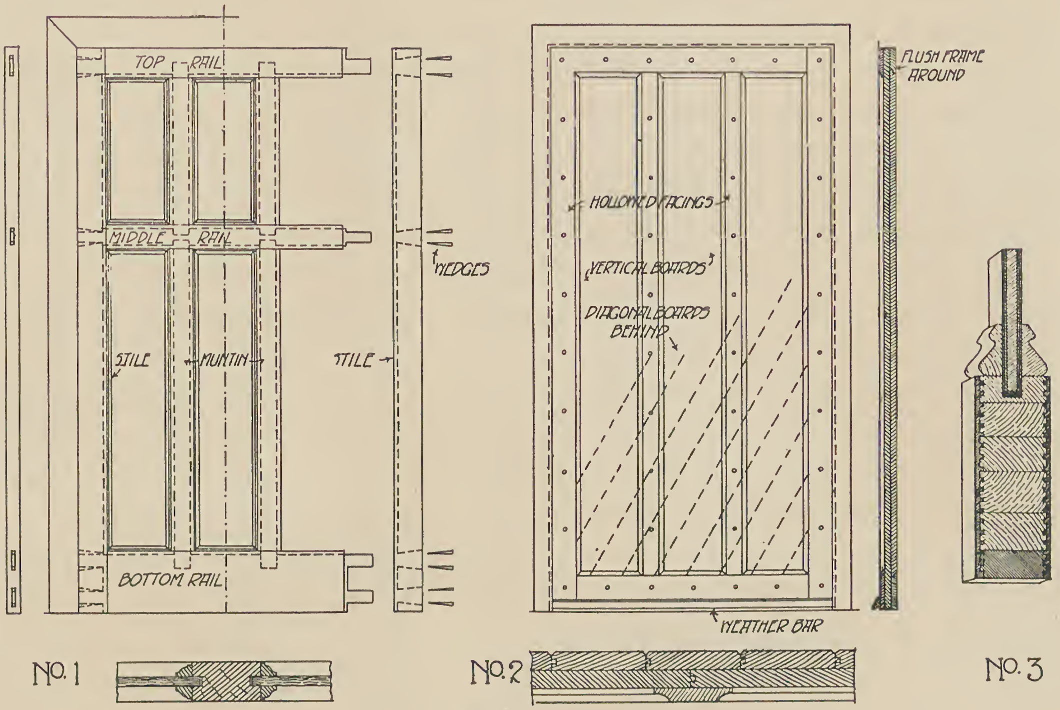


Fig. 94.—Doors.

No. 1 is an ordinary panelled and moulded door, and No. 2 an external door constructed with vertical and diagonal match-boarding nailed together, and with hollowed facings planted on outside to form panels. A throated weather-bar is planted on the bottom rail to exclude driving rain. No. 3 is a section

showing the method of construction adopted by the Gilmour Door Co. to prevent shrinkage and warping. The framing is composed of a number of pieces glued and tightly pressed together, and faced with hardwood veneers tongued and grooved to the core as shown. The panels are finished with flat cross-ply veneers, and the mouldings are of solid hardwood. For hospitals a perfectly flat door veneered on both sides, and without panels or mouldings or visible joints, is now often used.

External doors should be made of good red deal or of one of the hardwoods —oak, mahogany, &c.; internal doors are sometimes made of pine, but red deal framing is better, with panels perhaps of pine or canary wood. Pitch-pine is so liable to shrink and warp that it cannot be recommended. The usual hardwoods are of course the most beautiful and durable, but their cost is often prohibitory. Undercut moulds around the panels should be avoided, on account of the difficulty of cleaning them; indeed a special panel for hospital doors has been designed, in which every angle and corner is rounded to prevent the lodgment of dust and germs and to facilitate cleansing.

Where the ventilation of the house has been duly considered, draught-excluders, which largely prevent the entrance of dust, may with advantage be fixed on all external doors. It is a good plan to fix rounded oak thresholds about 2 inches wide and $\frac{3}{8}$ inch thick under all internal doors, so that the doors, while fitting closely to the thresholds, will open clear of the carpets. A feature of internal doorways, which ought to be more frequently adopted for purposes of ventilation, is the hinged overlight, made to open and close at will; examples of these are given in Plate II.

For large mansions, **fire-resisting doors** may be necessary in different parts of the building; these may be of wrought-iron or steel, or (better) of two or three thickness of wood boards covered with thin sheet metal. Sheets of compressed asbestos, known as "uralite", are sometimes inserted between the boards and the metal. In London, "oak or teak or other hard timber, not less than 2 inches thick", may now be used for fire-resisting doors, and also, it may be added, for fire-resisting stairs.

3. *SKIRTINGS, PLINTHS, &c.*

Skirtings are usually of wood, moulded on the top edge, and fixed to form a sort of base or plinth to internal walls. As a rule, they are nailed either directly to plugs driven into the wall, or to wood grounds nailed to breeze bricks; the latter is the better arrangement. Frequently wood skirtings shrink

after being fixed, and a wide open joint appears between them and the floors, forming a most insanitary harbour for dirt and vermin. In order to prevent this, the floor-boards should be ploughed to receive the skirting, as shown at A in fig. 95. A better form of wood skirting is given at B; the hollow member at the bottom—which ought to be nailed to the floor only and not to the skirting,—does away with the dirt-collecting right-angle and crevice between floor and wall, and prevents chairs being placed so close to the wall as to damage the wall above by their backs. The first coat of the plaster on the walls should be continued quite down to the floor before the skirting is fixed.

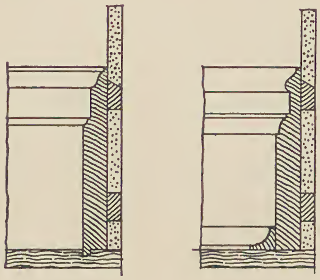


Fig. 95.—Wood Skirtings.

Cement skirtings are more expensive than wood and are somewhat apt to chip, but they are hygienically much more satisfactory, as they afford no hiding-place for vermin and do not decay. They may be of Portland cement or of plaster of Paris, or one of the varieties of this material,—Parian, Keene's, Martin's, and Robinson's cements.

Glazed bricks and tiles are excellent materials for the plinths of cloak-rooms, bath-rooms, and water-closets. Examples are given in fig. 42 page 91, fig. 51 page 115, and in Plate II.

Wainscot is a wooden casing or lining to walls, and may be formed with tongued-and-grooved or rebated boards (usually with beaded or V-shaped joints), with a moulded top-rail, or may consist of more or less elaborate panelled and moulded framing with moulded plinth and capping (fig. 96). In either case, wood grounds are fixed to the walls to receive the wainscot. To prevent draughts and dirt, one coat of plasterer's "rough stuff" may be applied to the walls after the grounds are fixed, but this must be thoroughly dry before the wainscot is put up, or the wood may swell and twist; an additional precaution consists in painting the back of the wainscot before fixing it.

Chair-rails are narrow pieces of wood, usually moulded, fixed to walls at the height of the top of a chair-back to prevent the chairs damaging the walls. Sometimes they are grooved on the top, so that plates, photographs, &c., can safely be placed thereon. The groove, however, should be wide, or it is difficult to keep clean.

Picture-rails are the modern substitutes for the picture-rods of our fathers. They are shown in Plates II., III., and V. They are simply moulded pieces of

wood nailed to wood plugs or grounds, and having a groove in the upper surface to receive picture-hooks. This groove undoubtedly collects dust, although this disadvantage may be modified by forming it in the lower part of the rail, instead of on the top as usual.

4. *STAIRS.*

Stairs in houses are usually of wood framed together in the manner shown in fig. 96. The raking pieces at the sides of the steps are known as "strings", and are grooved on the inner sides to receive the vertical boards, known as "risers", and the horizontal boards, known as "treads". In good work the risers are tongued on both edges into the treads above and below, and the projecting edges of the treads are moulded and in many cases small bed-moulds are planted under them. The treads and risers are fixed in the grooves of the strings with wedges, and are also screwed to the strings; small blocks of wood are usually glued into the angles under the treads and behind the risers, and wide and long flights are supported on fir "carriages", rising from the trimmer or joist at the foot of the stairs to the trimmer at the landing. The illustration shows a staircase with open well, the upper flight having moulded soffit boards instead of the usual lath and plaster, and the strings being of the kind known as "close". Sometimes the strings are cut out in the upper part so that the treads and risers pass over them. The balustrade consists of a handrail, supported on turned and moulded balusters and framed into newels at the foot of the stairs and at the angles of the well.

The height of the riser should be proportioned to the breadth of the tread, the following being a good rule:—Breadth of tread + twice the height of riser = 2 feet. It is not customary, however, to have risers less than 5 inches or more than 9 inches. Turnsteps or winders are a source of danger; so also are odd steps in unexpected places.

Fire-resisting stairs are occasionally constructed with solid steps of oak or other hardwood, built into the walls after the manner of stone steps. In London, stairs are deemed to be fire-resisting if made of "oak or teak or other hard timber, with treads, strings, and risers not less than 2 inches thick". No. 2, fig. 96, shows the "Kleine" fire-resisting stairs, constructed of hollow-bricks, iron tension-rods and concrete, in the same way as the flooring shown in fig. 92, page 173. The treads and risers may be of wood, as illustrated, or of marble, tiles, or other suitable material. Sometimes re-inforced concrete is used for the structural part of fire-resisting stairs. Solid stone steps are apt

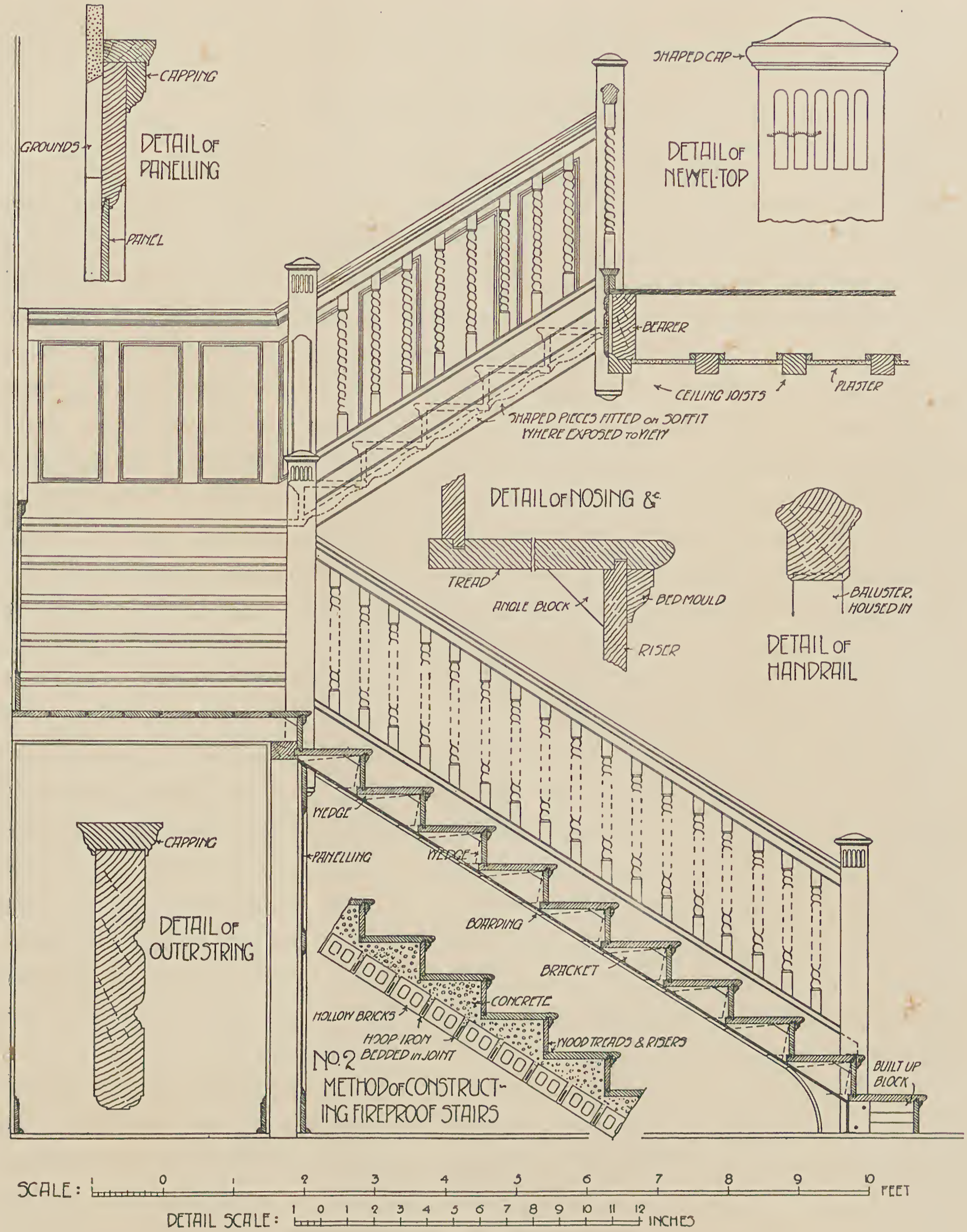


Fig. 96.—Stairs.

No. 1, Wood; No. 2, Hollow-bricks, Concrete and Wood.

to crumble and snap in a severe fire, and are not as safe as the "Kleine" stairs and others of somewhat similar type.

CHAPTER X.

PLASTER, WALL-TILES, &c.

Plaster is the popular name for the ordinary covering of lime and sand applied to internal walls. Technically, the word "plaster" often signifies plaster of Paris. Ordinary plaster consists of slaked lime and sand. The lime is a "fat" lime, devoid of hydraulic properties, and slaked by being mixed with a large quantity of water and allowed to stand in a "pit" for some weeks,—the longer the better. The sand should be free from clay, soot, organic matter, and other impurities, and must be washed before being used if these are present. Sea-sand must be avoided, as the salt in it has a great affinity for moisture. "Two-coat" work consists of a first coat of *coarse stuff* —*i.e.* slaked lime and sand mixed in the proportion of about one to three, a little cow-hair being usually added to bind the mixture together,—and a second and much thinner coat of *fine stuff* which contains only a little sand. "Three-coat" work ensures a truer and better surface, and consists of a first or "rendering" coat, a second or "floating" coat, and a third or "setting" coat. The last coat may be finished either with a wooden float or a steel trowel, the latter giving the smoother surface.

On ceilings and wood partitions it is necessary to provide a backing, to which the plaster will adhere. This is usually formed with **laths** of oak or fir about an inch wide, and nailed to the studs or ceiling-joists about a quarter of an inch apart. Single laths are about $\frac{3}{16}$-inch thick, lath-and-half $\frac{1}{4}$-inch, and double laths $\frac{3}{8}$-inch. More fire-resisting substitutes for wood laths may be obtained in the form of Johnson's metal lathing, Banks's "Helical" metal lathing, and the "Expanded" metal lathing, all of which have been severely tested in actual fires. Another form of metal lathing is the "Jhilmil", but this contains much more metal than any of the others.

Ordinary plaster is undoubtedly porous, and absorbs both moisture and organic matter. Sir Douglas Galton says that "in a discussion, in 1862, in the French Academy of Medicine, a case was mentioned in which an analysis has been made of the plaster of a hospital wall, and 46 per cent of organic matter was found in the plaster". This is scarcely credible, but undoubtedly contamination by organic impurities given off by the lungs and skin does take place, and may prove a source of discomfort and ill-health. A harder and more impervious wall-covering may be obtained by using either **Portland cement,** or one of the so-called "cements" which have **plaster of Paris** for their base,

—Martin's, Keene's, Parian, and Robinson's cements. These have the further advantage that they set rapidly. It must not be forgotten that the ordinary plaster transmits sound much less readily than a hard and dense cement.

Sirapite is a special plaster which is now largely used. It saves time, as two coats only are required, and the second coat can be applied a few hours after the first; it also sets more firmly than ordinary plaster. On damp walls, however, whether in basements or above ground, it must not be used. For the first coat on walls, one measure of sirapite is mixed with three or four measures of clean sand, and for the first coat on lathed ceilings and partitions, two measures of sirapite to one of sand are used, or, for the best work, equal quantities of the two materials. For the finishing coat sirapite is used without sand. Some plasterers add a little "lime-putty" to the first-coat stuff, but the quantity ought not to be more than a half-pail of lime-putty to every four pails of the mixture of sand and sirapite. The materials must be mixed in a banker in small quantities. As a rule the thickness of sirapite plastering is less than that of ordinary plastering, and sound is transmitted through it more easily. Sawn laths, nailed $\frac{3}{16}$-inch apart, are recommended for ceilings and partitions in order to economize material.

Antiseptic Manila fibre is now coming into use as a substitute for cow-hair in plaster. It is treated with an antiseptic solution and cut into lengths of about $1\frac{1}{2}$ or 2 inches. Its great strength is a point in its favour, and for hygienic reasons also it is to be preferred.

The danger of occupying newly-plastered houses is a very real one, and it would be a blessing if sanitary authorities were careful to withhold certificates as to the suitability of houses for occupation, until the walls were thoroughly dry. Dr. Richardson has said: "I once visited a new and pretty row of houses in a London suburb to see a young lady there who was suffering from pulmonary consumption. The house was literally saturated with moisture. This patient died from the disease that had been lighted into activity there. On making further inquiries, I found that in the same row of houses, twenty in number, there occurred within the first two years of their occupation six other instances of pulmonary consumption and fourteen instances of acute rheumatic fever." Here is the case of another lady,—a confirmed cripple from rheumatic disease following upon acute rheumatic fever. "Newly married, she and her husband bought a new house, which, in their desire to settle quickly, they inhabited while the walls were still bedewed with moisture. She sickened with acute rheumatic fever, and never fully recovered from its effects. Worse than all, every one of her children—and she gave birth to seven after her attack

—were affected with rheumatic disease, three dying from heart affection dependent upon the rheumatic constitution." Before occupying a new house, fires should be constantly maintained in all the rooms for several weeks, and streams of air should be passed through the rooms, by keeping all windows and internal doors constantly open, whenever the weather permits. Sunshine and change of air are powerful aids to dryness; indeed, without change of air, fires will be of little service. If the bricks and stone, of which the house was built, were thoroughly soaked with moisture before the plaster was applied, drying may be a question not of weeks but of months.

Plaster moulds and enrichments are often receptive of dust and difficult to clean, but undoubtedly a great change for the better has taken place in this respect. The days of deep hollows in cornices, and of "bold" enrichments, appear to be numbered, and taste has reverted to the more refined detail of a century or two ago. A simple but effective cornice, without any dirt-catching members, was illustrated in fig. 74, page 145, and others are shown in Plates III. and V. The proper treatment of plaster lies undoubtedly in elaboration of surface, and not in constructing massive beams and ornament in high relief.

Fibrous plaster has a plaster face on a canvas backing, and can be obtained in plain slabs of various sizes, which are simply fixed to the wood ceiling-joists or studs by screws. A thin coat of Keene's cement, applied to the whole, covers the joints and renders the surface uniform. A great saving of time is effected by the use of fibrous plaster slabs, and the house can be safely occupied much sooner than when ordinary plaster, or even cement, is used. Ornamental fibrous-plaster slabs are now made in endless variety to architects' designs, and are fixed to form the ceilings and friezes of important rooms.

Glazed wall-tiles are now largely used in bath-rooms, lavatories, water-closets, sculleries, pantries, vestibules and halls, &c.; they are made in numerous plain colours, or decorated and embossed in a variety of ways, the more expensive tiles being hand-painted. They are laid on walls on a bed of quick-setting cement, the joints of the brickwork being first raked out to afford a key for the cement. The backs of the tiles have sometimes undercut recesses, which, when the tiles are pressed into the wet cement, obtain a firm hold, and prevent the tiles falling off. Wood partitions, on which tiles have to be laid, may first be boarded, and the tiles fixed by brass-headed screws at the corners, each screw-head catching the corners of four tiles. Special tiles, however, have been devised, which dispense with these visible screws. Fig. 97 illustrates Hall's new improved patent hanging-tiles, fixed to wood battens by nails or screws passing through the holes C C. The two nails in each tile are covered by the

tiles in the course above. When these tiles are used for walls, they are bedded on neat Portland cement, and firmly secured by pressing the tile against the wet cement, so that some of the cement passes through the splayed holes at A A, forming a dove-tail key. The tiles are made in stretchers ($9'' \times 2\frac{7}{8}''$ on face),

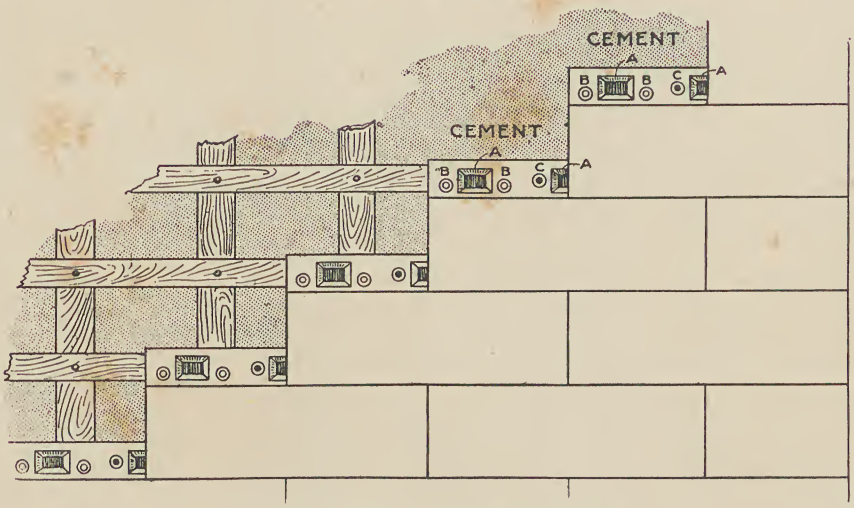


Fig. 97.—Hall's New Improved Patent Hanging-tiles.

headers ($4\frac{1}{2}'' \times 2\frac{7}{8}''$ on face), and in square and bull-nosed quoins; tiles $6'' \times 6''$ on the face are also made.

Glass Tiles.—"Opalite", "Newellite", and other thin tiles of various colours have been extensively used during recent years for wall-surfaces, and are well adapted for bath-rooms and other rooms where washable walls are desired, as they can be laid with very fine joints. They are glass or porcelain plates, about one-sixteenth to one-eighth of an inch thick, and can be attached to walls after the manner of tiles. The plates need careful bedding, or cracks will be sure to occur sooner or later. In some varieties the backs are covered with small fragments of glass or sand to assist adhesion, and are bedded in a special composition on a rendering of cement.

Emdeca is the trade-name given to sheets of enamelled zinc. It is usually made in patterns to imitate tiles, but the material is not as satisfactory as good tiling or glass tiles, although it has the advantage of being more easily applied to ordinary plastered walls.